MY FAVORITE NUMBER IS THE COLOR GREEN: IMPLEMENTING GREEN WALLS IN A RESIDENTIAL SETTING TO IMPROVE CHILDHOOD DEVELOPMENT

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ABSTRACT

The modern world is characterized by human expansion, resource consumption, and technological advances. Rampant development has created a rift in the human-nature connection, a relationship once coveted during the earliest days of mankind. This kinship must be reestablished to ensure a healthy lifestyle. Immersion in the natural world provides the ideal environment for childrearing. Natural surroundings supply various stimuli to serve as catalysts for educational theories and environmental psychology. These benefits promote better childhood development and reinforce the principles of biophilic design. One solution for rekindling the human-nature connection and promoting a healthier lifestyle is through the implementation of green walls in a residential setting.

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1.0 PROJECT STATEMENT

Life as an adult is largely dictated by the events experienced as a child. The upbringing of an individual impacts their social, mental, and physical capacities. Every environment a child interacts with, whether at school, in the home, indoors, or outdoors, can potentially affect their development. A parent's concern should be to give their child the most enriching lifestyle possible. As such, exposure to natural environments can contribute to healthy behavior and habits. Realistically, complete immersion is not feasible on a daily basis, and as such, measures must be taken to introduce nature back into the built environment. One of the most promising ways to reinstitute natural surroundings is through the implementation of green walls.

In modern times, there has been a large disconnect between the built and natural environments. The built environment tends to exert control over the natural landscape. Hills are leveled, streams and rivers diverted, and vegetation cleared to pave the way for new structures. Particularly in urban areas, but also extending into suburban districts, children are presented with fewer opportunities to engage natural surroundings.

The increase of industrialization also brought with it the recognition of the therapeutic qualities of the natural world. Nature-related activities were coveted for their regenerative and stress-reducing effects. It was not uncommon for city dwellers to travel for extensive periods of time to reach remote destinations. These sites were often typified by lush forests, pristine lakes, and rolling mountains. Activities such as camping, hiking, and fishing even served to strengthen family relationships and communication.

There is a growing concern over youth of today's society falling prey to consumer culture. Technological devices such as cell phones, computers, tablets, and handheld gaming systems are constantly releasing new models, and as such, younger generations invest much of their free time in electronic media. Older generations fret over the lack of youngsters' contact with the natural world and fear they will not learn to take pleasure in the simple things in life, the value of physical activity, or the ethic of hard work.

Understanding human interaction with their surroundings entails environmental psychology. Various processes such as arousal, overload, affect, adaptation, and personal control determine the value of any activity in regards to its respective environment. Many of the environmental psychology theories focus on providing adequate stimuli without being overwhelming, which would lead to overstimulation, or enough stimuli to hold a person's interest. After examining these theories and environmental perceptions, commonalities surface which make it abundantly clear that human beings tend to favor certain aspects of the environment. People intrinsically look for complexity for interest, rationalization and recognition of patterns in those complexities, and obtain an understanding as a precursor to grasping future situations. Environmental psychology benefits greatly from incorporation of natural settings. They are an excellent source of diverse stimuli presented in subtle ways so as not to overstimulate a viewer.

Environmental psychology governs the why and how individuals interact with the environment. Translating those experiences into a means by which children learn is governed by educational theories. The earliest educational theories were created by great minds like Plato (428-348 B.C.) and Aristotle (384-322 B.C.). Plato developed *rationalism* which posited that knowledge could be gained simply by contemplating on the subject. No external stimulus was needed, just abstract ideas that could be developed into notions and ideals through careful though. Aristotle, Plato's disciple, expanded upon rationalism to account for environmental stimuli. His theory, deemed *empiricism*, focused on the importance of interaction with surrounding environment. External input was needed as a catalyst for thought and reasoning, and a precursor to the development of concepts and notions.

As educational theories progressed through contemporary times, the role of environment became increasingly significant. The *functionalist* theory based all reaction on a stimulus-response stratagem. A stimulus presented evokes a particular response, and in turn, triggers a series of conjoined stimulus-response based actions. However, it proved too broad a concept and paved the way for the *behavioral* theory. Behavioral theories emphasized the importance of reinforcement, both positive and negative, to interactions

of a child with their environment. *Constructivist* theories highlight the importance of environmental interaction and promote an individual's need for exploration and self-education. Even *cognitive* theories, steeped in hierarchical ordering, categorization, and memorization can benefit from natural environments. As educational theories have progressed, the importance of the surrounding environment has dramatically increased. Each theory will benefit from exposure to the natural world.

Natural surroundings present the most diverse range of sights, sounds, smells, and textures which cater to a child's instinctive need for discovery. Exploration of the natural world has been linked to increased self-esteem, independence, a better ability to cope with difficult situations, effectiveness, and a likelier chance to take risks. Cultivating better coping skills fosters enhanced responsibility, efficiency, organization, and perseverance. Formation of these traits will make an individual more likely to take responsibility for their own education and learning experiences. The natural world has an infinite amount of variation that caters to cognitive functions as well. Leaves of the same tree may be similar, but closer scrutiny reveals small nuances that prevent any two leaves from being exact replications. This type of investigation leads to better ordering skills, categorization, memory capacity, and critical thinking. Vertical gardens, if designed correctly, can boast all of these benefits.

Transfer is another important aspect of childhood development. Transfer governs the acquisition of skills relevant to subjects like science, math, or social studies and how they are applied in similar or new situations. Types of transfer typically exist in dualities and there are six types of transfer: near and far; literal and figural; high-road and low-road. High-road transfer has two subcategories deemed forward-reaching and backward-reaching transfer. Each duality deals with acquired skills and how they are applied in similar situations or new, interrelated scenarios. Vertical gardens have the potential to trigger numerous types of transfer. Landscape in a nonconventional vertical fashion promotes creativity, imagination, and critical thinking. Vertical gardens also enlighten children on natural occurrences such as the passage of time, life and death, growth, other processes. They deal with overlapping principles of botany, biology, chemistry, physics,

and can even entail mathematics and engineering when considering water delivery or structural supports.

Vertical gardens enhance all three facets of childhood development: cognitive, affective, and evaluative. Cognitive development entails six stages: knowledge, comprehension, application, analysis, synthesis, and evaluation. The process describes accumulation of knowledge by children and how they convert it to understanding. Affective development depicts a child's emotional development and occurs in five stages: receiving, responding, valuing, organization, and characterization by a value of complex value. Evaluative development governs a youth's formation of values and the ability to adjust them as necessary. Values created are based on the nine values of biophilia: aesthetic, dominionistic, humanistic, moralistic, naturalistic, negativistic, scientific, symbolic, and utilitarian. Each tenet portrays how a child views nature.

Children are particularly explorative and their curiosity often leads them to investigate the natural world. While this interest in the natural environment will continue well into adulthood, it is important for kids to experience it while their opinions and impressions are wholly unbiased. Between infancy and adolescence, young individuals will develop a wide range of physical, cognitive, and social skills as a result of interaction with their environment. Dealings with their surroundings will vary as they gain mobility through crawling and walking which will allow for greater travel distances. The farther they can travel on their own, independent of a parental figure, the better and more immersive their experience in nature will be.

Children develop different views in several developmental periods. The first occurs between ages three and six and predominantly involves formation of utilitarian, dominionistic, and negativistic values. The second period occurs during middle childhood between the ages of six to twelve years of age and establishes humanistic, symbolic, and aesthetic values. The third developmental period takes place between thirteen and seventeen years of age. During this time moralistic, naturalistic, and scientific values surface.

Vertical gardens have the capacity to benefit much more than childhood development and increase physical, mental, and social health. Vertical gardens encourage outdoor play and exploration which helps to combat sedentary behavior, an all too common occurrence in children of today. Physical activity increases stamina, strength, and overall fitness. Outdoor activity is critical for development of necessary motor skills and can boost a child's immune system far better than sterile indoor environments. A visual connection to nature can even shorten recovery time from illness or injury.

Many gains to mental health are also a result of vertical garden implementation. The presence of natural elements can increase attentiveness, improve cognition, and reduce stress. Natural surroundings often provide a tranquil and relaxing environment and are conducive to creativity, imagination, and problem solving. Vertical gardens have the potential to lessen the cases of attention deficit disorder (ADD) and attention deficit hyperactive disorder (ADHD). Both disorders are thought to be the result of children lashing out after being cooped up indoors for extended periods of time.

Children who interact with natural surroundings and vertical gardens show enhanced social skills. Play in natural areas fosters imaginative play, cooperation, collaboration, fair play, independence, and democratic skills. Vertical gardens and other natural amenities allow children to escape the confinement of indoor environments, provide a place to meet with peers, and help children to learn about themselves and the natural world around them. Socializing in natural settings results in lower sickness rates and reduces chances of depression.

The benefits and advantages of vertical gardens can be better understood by defining biophilic design. Biophilic design encompasses mankind's affinity for nature. There are two dimensions of biophilic design: organic or naturalistic, and vernacular or place-based. The two dimensions are divided into six elements that include environmental features, natural shapes and forms, natural patterns and processes, light and space, place-based relationships, and evolved human-nature relationships. These six elements are further broken down into seventy-two biophilic attributes.

For the purpose of this project, vertical gardens have been classified into three categories: façade greening, planter walls, and green walls. Façade greening is the most traditional method of vertical gardens and utilize vines, clingers, and climbers employed on exterior surfaces or support structures. Planter walls are the least common and depict pots or planter boxes mounted on a sturdy support structure. Green walls are the newest innovation and increasing in popularity. Green walls transform vertical surfaces into the actual growing medium and do not always require conventional soil.

Common advantages shared by all three vertical gardens are pointed out and then each type is examined individually. Façade greening, planter walls, and green walls have their own merits and drawbacks. Each type will be evaluated based on the biophilic attributes they encompass or could potentially utilize. A score was created for each variation and green walls were deemed the most valuable since it employed the most biophilic traits.

Green walls, while boasting the highest score, still have the potential to become better tools for the promotion of better childhood development and human comfort. While green walls are valued for their aesthetics and healthful benefits they can be viewed as flat wall treatments. To provoke more interest and exploration of green walls, interactive, and interchangeable, elements will be added to accommodate the different stages of childhood development and the pertinent values of biophilia associated with each age group. Design implications are made, but it is important to note that they are suggestions or components and not a holistic design. Suggestions will be made for future research and the significant potential of green walls as applied to other building types will be highlighted.

2.0 ENVIRONMENTAL PSYCHOLOGY

Every environment a child engages is a potential learning situation. In order to understand the latent knowledge a situation may provide, it is important to gain an understanding of environmental psychology. Environmental psychology studies how and why individuals react to their surroundings in different ways. It can be used to explain the principles of learning, motivation, perception, attitude formation, and social interaction.[1] Mankind's earliest existence entails observation of weather patterns, terrain, and animal behavior. Meticulous scrutiny led to responses such as the stockpiling of food, building of shelter, and hunting techniques. These early interactions with the surrounding area served as the basis for environmental psychology. In the present day, mankind is prone to altering the environment to suit needs rather than adjust to existing conditions. This has led to a whole slew of new responses in regards to human activity within the surrounding context.

Environmental psychology is governed by several perspectives that influence any field of psychology. These views share a close link with educational theories, which will be discussed in the upcoming section, and are indeed the basis for several theories. The *cognitive perspective* posits that human knowledge and comprehension is brought about through the relationships shared with their environment. The *humanistic perspective* favors free will and the desire for self-actualization, or a need to transcend basic needs.[2] The *learning* or *behavioral perspective* depicts past experiences influencing future actions. The *neurobiological perspective* holds that human action is based on preconditioned neurological or biological responses. The *sociocultural perspective* suggests that social conditions such as status, gender norms, expectations, cultural traits, and heritage produce certain behaviors.[3] There are differing speculations as to whether these perspectives are experienced individually or several at once. Children immersed in

[1] Dak Kopec, *Environmental Psychology for Design* (China: Fairchild Publications, 2006), 7.
[2] Dak Kopec, *Environmental Psychology for Design* (China: Fairchild Publications, 2006), 4.
[3] Dak Kopec, *Environmental Psychology for Design* (China: Fairchild Publications, 2006), 4.

direct or indirect contact with natural surroundings have the potential to benefit from all perspectives.

A child allowed to play in the garden makes cognitive gains by experiencing new colors, shapes, smells, and sights. The humanistic perspective encourages the youngster to explore freely and manipulate leaves, branches, and vegetation. Behavioral views force the child to proceed cautiously due to prior experiences with thorny plants or insects. Discovery of a bee's nest or other potential hazard cause a neurobiological response to release chemicals and a child will instinctively flee for safety or sanctuary. The socialcultural perspective teaches children to take responsibility for the well-being of plants, animals, and other living organisms. The ability of natural environments to engage all perspectives of psychological development make them invaluable to childhood development.

A child's experience with their surroundings is further augmented by five fundamental psychological processes. *Arousal* describes excitement or stimulation in expectation of physiological activity. *Overload* depicts a negative result from excessive stimulation or activity. *Affect* portrays emotional response to the environment. *Adaptation* encompasses the process of adjustment to environmental conditions.[4] *Personal control* denotes a child's ability to physically manipulate their environment. These processes affect the outcome of a child's benefit, learning experience, and overall enjoyment of interactions with their environment. These processes are further outlined in Table 1.

Natural surroundings generally evoke all psychological processes but limit overload. Even park-like scenes, although commonly large in scale, present a tranquil and serene setting so as not to provide stimuli in an overbearing fashion. Overload can occur if a child is placed in a natural area of immense scale such as Yellowstone National Park. Built environments which cater to children, such as attractions like Disneyland, purposely use bright, contrasted colors to seemingly encourage overload. The converse may also be true. Built areas may not provide enough diversity in stimuli or objects to manipulate and

[4] Dak Kopec, *Environmental Psychology for Design* (China: Fairchild Publications, 2006), 13.

children may quickly lose interest.

PSYCHOLOGICAL STATE	PROCESS	BEHAVIORAL OUTCOME
Arousal	Behaviors are linked to physiological responses.	Ranges from hyper- to hypostimulation
Overload	Too much stimulation	Fight, flight, or withdrawal
Affect	Memory, sensation preferences	Emotional reaction to the environment
Adaptation	Adjustment to stimulation levels	Desire for certain levels of stimulation
Personal control	Influence over external stimulation	Ranges from successful coping to learned helplessness

Table 1: Environmental Psychology Processes and Their Expected Outcomes[5]

2.1 ENVIRONMENTAL PSYCHOLOGY THEORIES

The perspectives and processes of environmental psychology led to the formation of theories. These theories help to form an understanding of how individuals experience their surroundings. Environmental psychology focuses on four major theories: *integration*, *stimulation*, *control*, and *behavior-setting*.[6] These theories provide a foundation for successful design whether it be in the built environment, or as it pertains to this project, recreation or simulation of a natural setting.

Integration theories utilize five elements to describe the human-environment relationship. *Global environment* describes the generalized characteristics of an environment. *Instigators* refer to environmental stimuli which elicit specific behaviors. *Goal objects and noxients* encompass situations of both satisfaction or displeasure. *Supports and constraints* define environmental aspects which promote or restrict a child's behavior.[7] Integration theories use these elements, along with human conditions, to explain environmental interaction. Human factors that can affect the richness of an experience are outlook, health, past encounters, and disposition of others in the immediate context.

Control theories focus on human manipulation over various components of the environment. Control appears in three types: *behavioral*, *cognitive*, and *decisional*.

[5] Dak Kopec, *Environmental Psychology for Design* (China: Fairchild Publications, 2006), 26.
[6] Dak Kopec, *Environmental Psychology for Design* (China: Fairchild Publications, 2006), 19.
[7] Dak Kopec, *Environmental Psychology for Design* (China: Fairchild Publications, 2006), 20.

Behavioral control allows for the adjustment of the environmental event, cognitive control is the ability to change the way one perceives an environment, and decisional control focuses on the formation of responses.[8] Personal control, as previously mentioned, provides a feeling of freedom and mastery and leads to much more enriching experience.

Behavioral-setting theories focus on situation-appropriate conduct. These theories rely heavily on operant conditioning, which dictates the formation of socially acceptable behaviors for various events or settings.[9] Children are encouraged to run free and explore in outdoor natural environments but are discouraged from doing the same indoor where small spaces may be confining or furniture and fixtures may be damaged. These behaviors may vary based on activity even if in the same setting. A child may be encouraged to play aggressively during a sports event in an outdoor setting, but will display gentler behavior if playing with friends or siblings in the same environment. Children who partake in explorative play in natural environments will learn to care for other living entities such as plants and animals. Emotional investiture in the well-being of living objects will translate to other situations, for example, if a stranger under duress requires aid.

Stimulation theories depict the surrounding environment as stimulus in the form of sight, sound, smell, taste, and touch. Most situations will stimulate sight, sound, and smell, but all five senses have the capacity to be overstimulated (hyperstimulated) or understimulated (hypostimulated).[10] Undersimulation should be avoided when possible since it has been proven to be detrimental to childhood development.[11] Lack of stimuli will fail to capture a child's interest and may even lead to attention deficit issues. Physical, psychological, and energy can be restored in the presence of nature, which has been proven to reduce stress and restore attentiveness.[12] Humans have an affinity for

[8] Dak Kopec, *Environmental Psychology for Design* (China: Fairchild Publications, 2006), 20.
[9] Dak Kopec, *Environmental Psychology for Design* (China: Fairchild Publications, 2006), 22.
[10] Dak Kopec, *Environmental Psychology for Design* (China: Fairchild Publications, 2006), 23.
[11] Dak Kopec, *Environmental Psychology for Design* (China: Fairchild Publications, 2006), 24.
[12] Dak Kopec, *Environmental Psychology for Design* (China: Fairchild Publications, 2006), 24-26.

objects that are involuntarily interesting. Scenic landscapes, lush gardens, and park-like settings captivate attention, but also instill a sense of calm and relaxation.

2.2 ENVIRONMENTAL PERCEPTION

Along with environmental psychology theories, several views have been developed by psychologists to better comprehend how individuals perceive their environment. Egon Brunswik created his *probabilistic lens model* to this effect. Brunswik laid out a theoretical framework that views human-environment relationships holistically and can be used to analyze a subjective interpretation of the environment's beauty or usefulness.[13] Perception was compared to a lens in which stimuli are focused, but only have a probability of being of value.

The probabilistic lens model uses two types of clues to differentiate between actual and perceived beauty. Distal cues, which are characteristics of the setting, are used to interpret actual beauty. Proximal cues, which impose an observer's subjective impressions upon the situation, determine perceived beauty.[14] The relationship between distal and proximal cues are further outlined in Table 2. Under Burnswik's model, individuals experience discomfort if placed in surroundings that contain components or patterns that are unfamiliar. New stimuli may lead to incorrect perceptions of size, height, color, or angle. It is important for children to engage natural surroundings whenever possible. The diverse range of stimuli in nature will build up their knowledge base and provide a better chance to perceive new situations.

James J. Gibson developed his *affordance* perspective which suggests that rather than viewing individual functions in an environment, humans organize features into recognizable patterns.[15] Gibson's view postulates that environments are composed of substances, surfaces, and textures which trigger cognitive functions leading to instantly recognizable scenarios. The affordance perception holds that humans favor ecologically

[13] Dak Kopec, *Environmental Psychology for Design* (China: Fairchild Publications, 2006), 26.
[14] Dak Kopec, *Environmental Psychology for Design* (China: Fairchild Publications, 2006), 28.
[15] Dak Kopec, *Environmental Psychology for Design* (China: Fairchild Publications, 2006), 28.

structured environments rather than individual features or cues. Some features are easily recognized while others may be misinterpreted. For example, a flower garden is seen as a quiet space for meditation, source for fresh flowers, a relaxing area to work, and even as a home to insects or source of food. Conversely, a wall or ledge intended as a boundary within a garden may be perceived as a seating area, skateboarding feature, or a display area.

THE SETTING	SELECTED DISTAL CUES	SELECTED PROXIMAL CUES	THE JUDGMENT
	Seating Arrangement	Crowded	
	Artwork	Elegance	
Actual Beauty	Floor Covering	Beauty	Perceived Beauty
	Furnishings	Comfortable	
	Lighting	Spaciousness	

Distal cues are related to actual beauty, while proximal cues are related to perceived beauty. Therefore, the goal of a designer is to positively relate the distal cues to the proximal cues. For example, does the seating arrangement foster perceptions of crowding or spaciousness?

Table 2: Brunswik Probabilistic Lens Model

The *collative properties* view was envisioned by Daniel Berlyne. His theory held that people respond to aesthetic properties such as *novelty*, *incongruity*, *complexity*, and *surprise*.[16] Novelty entails an innovative idea or a common application used in a unique way. Incongruity governs features that seem out of place or in the wrong context. Complexity refers to the amount of variation presented. Surprise portrays any unexpected occurrences, pleasant or otherwise. It is important to understand an individual's cultural background since their notions may differ from others. Americans may express surprise or view green walls as novelty, whereas Europeans, having employed facade greening for decades, may see green walls as a component of complexity but not a completely new trend.

Albert Mehrabian and James A. Russel developed the *pleasure-arousal-dominance* hypothesis. As the name suggests, humans display three primary emotions in response to

[16] Dak Kopec, *Environmental Psychology for Design* (China: Fairchild Publications, 2006), 29.

the environment: pleasure, which conveys positive feelings; arousal, showing excitement or anticipation of a challenge; and dominance, which affords individuals the ability to control their surroundings.[17] Russell further noted that people are attracted to environments that are moderately arousing and maximally pleasurable. Natural surroundings can present a diverse range of stimuli but with subtle changes in colors and characteristics. Such natural scenes evoke arousal, without overload, and present a very pleasurable environment.

Stephen and Rachel Kaplan proposed their *preference* framework explaining that people group environmental preferences into four categories: *coherence*, *legibility*, *complexity*, and *mystery*. Coherence looks for recognizable schema to produce understanding of an environment. Legibility depicts an individual's ability to decode scenes and comprehend the objects placed within. Objects with a dual purpose may hinder the potential to successfully grasp a situation. Complexity refers to the amount of variation present in an environment. Mystery entails hidden information of unknown components which beckon users to explore and discover.

The final model of environmental perception, derived by Kevin Lynch, was deemed *elements of legibility*. Lynch described five predominant elements which help the average person understand their environment and they include: *paths*, *edges*, *districts*, *nodes*, and *landmarks*.[18] Paths are avenues by which people navigate through an environment. They may not always be marked on the ground or bounded by walls, but nonetheless they are perceived as a means of egress. Edges consist of natural or manmade features that provide distinct boundaries. Districts are large areas that are easily identified by similar characteristics or functions. Nodes provide recognizable points within an environment and are often points of convergence for paths. Landmarks are visible, well-known elements that provide direction or point of orientation. Lynch's book, *The Image of the City*, stated:

[17] Dak Kopec, *Environmental Psychology for Design* (China: Fairchild Publications, 2006), 30.
[18] Dak Kopec, *Environmental Psychology for Design* (China: Fairchild Publications, 2006), 33.

> "Districts are structured with nodes, defined by edges, penetrated by paths, and sprinkled with landmarks.[19]"

There are a multitude of environmental psychology and perception theories, each with their own ideas and concepts. An outline of the theories and perceptions discussed is provided in Table 3. While sifting through the seemingly endless amount of terms, it becomes apparent that many share common elements. Berlyne's collative properties and Kaplan and Kaplan's preference framework both utilize the term complexity, and in both instances, convey the same definition. Both Kaplan and Kaplan's framework and Lynch's theory play off of the term legibility, and again in both cases, the term has a common definition. Whether it be mystery or surprise, control or dominance, reoccurring themes become evident and emphasize their importance. These commonalities form the basis for educational theories. Educational theories utilize environmental psychology and perception, and expand upon them, to explain the means by which children obtain knowledge.

[19] Dak Kopec, *Environmental Psychology for Design* (China: Fairchild Publications, 2006), 33.

THEORY	MAJOR PREMISE	KEY CONCEPTS	RELEVANCE FOR DESIGN
Social learning theory	Determines that we learn by first observing others and eventually reproducing their actions	Reciprocal determinism, modeling	Encourages an understanding of established societal norms
Integration (integral) theory	Elements of the environment work in harmony to facilitate a particular behavior	Global environment, instigators, goal objects and noxients, supports and constraints, directors	Offers a holistic approach to design
Control theory	Group of theories that address behavioral constraints and a person's perceived control over his or her actions and behaviors	Psychological reactance	Suggests that design elements lead to perceptions of control
Behavior-setting theory	Public places or settings evoke particular patterns of behavior	Operant conditioning, interactional theory	Emphasizes that design is an important component of a setting, which contributes to certain behaviors
Stimulation theory	Environment is a source of sensory information (stimuli) that leads to arousal	Threshold, arousal, environmental load, overload, adaptation level	Holds that design styles can lead to over- or understimulation
Attention restoration theory	Mental fatigue is caused by excessive directed attention, and attentional capacity can be restored by engaging in effortless attention	Directed (i.e., voluntary) attention, attentional deficit, effortless (i.e., involuntary) attention, restorative experiences	Include views of green spaces for effortless attention within environments demanding much directed attention
Probabilistic lens model	Stimuli from the environment become focused through our perceptions	Distal and proximal cues leading to cue validity and cue utility	Emphasizes the perceptual relationship between design and the human observer
Affordances	The world is composed of substances, surfaces, and textures, the arrangement of which provides instantly recognizable function (i.e., affordance) of environmental features	Environmental layout, contextual cues, direct perception	Highlights perceptual influences of design styles and probable dual uses of designs
Collative properties	We respond to aesthetics based on their collative stimulus properties (i.e., properties that elicit comparative or investigative responses and cause perceptual conflict with other present or past stimuli	Novelty, incongruity, complexity, surprise, hedonic tone, uncertainty-arousal	Claims that the joint nature of design elements merge to develop one overall impression
Pleasure–arousal–dominance hypothesis	Three primary emotional responses are translated to positive feelings, excitement or challenge, and control over the setting or situation. Later modified to use a circumplex model, with pleasure and arousal as the two main axes	Pleasure, arousal	Offers a method to evaluate environmental designs
Preference model	People prefer engaging scenes to boring scenes	Coherence, legibility, complexity, mystery	Offers a method for designing engaging environments
Elements of legibility	Five predominating qualities (i.e., elements) enhance its legibility to the average person	Paths, edges, districts, nodes, landmarks	Offers a method to enhance an environment's legibility

Table 3: Environmental Psychology Theories and Perceptions

3.0 EDUCATIONAL THEORIES

To better understand the importance of natural environments, general comprehension of educational theory must be obtained. Educational theories depict the means by which children interact with their surroundings, develop skills crucial to healthy maturation, and formulate ideas and concepts of the working world. It should be noted that environmental psychology theories differ from educational theories. Some underlining principles may sound similar, but environmental psychology deals with how and why people interact with the environment, whereas educational theories govern how individuals learn from those interactions. The educational theories discussed are but a few of the numerous ideologies but they cover a broader range of subjects. Many theories were developed in enclosed areas with preset stimuli or conditions to test specific outcomes, and as such, do not have much relevance to the importance of a human-nature relationship.

Contemporary learning theories stem from some of the most innovative minds in history. Figures like Plato (428-348 B.C.), Aristotle (384-322 B.C.), and Descartes (1596-1650) helped to shape the ideology behind the process of accumulating knowledge. Two of the earliest principles derived from these historical personas are *rationalism* and *empiricism*. Initial theories such as these, which discuss the relationship between knowledge and the environment, form the foundation behind contemporary educational theories.

3.1 RATIONALISM

Rationalism holds that knowledge comes from reason without the use of the senses.[20] Plato surmised a difference between knowledge gained through the senses and that gained from reason. A dualism is formed between external forces, and the creation of ideas. Material objects can be experienced using various senses whereas, ideas are formed through contemplation. This capacity to develop thoughts allows the creation of abstract ideas. Understanding an object can only come from close examination of the

[20] Dale H. Schunk, *Learning Theories: An Educational Perspective* (Upper Saddle River: Prentice-Hall Inc, 2000), 16.

concepts behind them. Plato insists that knowledge is innate and understanding comes from awareness through reflection which brings that knowledge to the surface.[21] Experiences through smell, touch, sight, taste, and hearing serve as input, but closer scrutiny and analysis transforms that raw data into ideas to be recalled later in similar situations.

The French philosopher and mathematician, Rene Descartes (1596-1650), Further solidified rationalism theories. He cast doubt upon everything he set out to prove so that once he arrived at a conclusion beyond all uncertainty, it must be true.[22] This line of thinking led to Descartes famous quote, "I think, therefore I am." Descartes used deductive reasoning to move from general premises to specific instances. He viewed the world as mechanical and human thought drives bodily functions. These thoughts are based on sensory experiences from previous interactions with the environment.

German philosopher, Immanuel Kant (1724-1804), extended the rationalist perspective by postulating that the world is disordered, but the human mind imposes order upon it.[23] Humans naturally receive sensory input from the surrounding environment and alter it according to innate beliefs. Kant held that the world could not be known as it truly exists, but only as it is perceived. He further theorized that absolute knowledge uninfluenced by the external world does not exist, and knowledge is empirical since it is derived from the environment but interpreted by the mind.[24]

Rationalism forms a duality between sensory information and the formation of ideas. Plato's philosophy claimed that knowledge can be obtained solely by reasoning. While his early theories were invaluable to his predecessors, rationalist perspectives evolved to account for a greater role of the environment. Descartes and Kant included the external

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[21] Dale H. Schunk, *Learning Theories: An Educational Perspective* (Upper Saddle River: Prentice-Hall Inc, 2000), 16.
[22] Dale H. Schunk, *Learning Theories: An Educational Perspective* (Upper Saddle River: Prentice-Hall Inc, 2000), 16.
[23] Dale H. Schunk, *Learning Theories: An Educational Perspective* (Upper Saddle River: Prentice-Hall Inc, 2000), 16.
[24] Dale H. Schunk, *Learning Theories: An Educational Perspective* (Upper Saddle River: Prentice-Hall Inc, 2000), 17.

world as a major influence. They asserted that the accumulation of knowledge was based on information acquired from the environment. The reliance on the surrounding environment as a source of input to stimulate the generation of values and beliefs is a common tenet of contemporary educational theories.

3.2 EMPIRICISM

Empiricism believes that experience is the only source of knowledge. Plato's disciple and eventual successor, Aristotle (384-322 B.C.), made no distinction between the external world and an individual's thoughts or perceptions. Rather than treat environmental input and analysis as separate entities, empiricism views it as one fluent process. The laws and rules governing nature are discovered through reasoning as sensory information is taken in.[25] Unlike his mentor, Aristotle believed ideas do not exist independently of the outside world, but rather, the external world is the source of all knowledge.

Aristotle's major contribution to empirical theories was his concept of *association*. The principle governs the triggering of an idea based on previous experiences which may have shared similar objects, environments, or subject matter. As ideas and objects are associated more frequently, the likelihood of one triggering memory of the other increases.[26] Associative learning components are often found in learning theories and share a close kinship to *transfer*, which will be discussed later.

British philosopher John Locke (1632-1704) made significant contributions to empirical theory. Locke postulated that humans have no innate notions, but rather, all knowledge is based on two types of experience: sensory impressions of the environment and personal awareness.[27] This is exceptionally true for young children. At birth, the human infant is a blank slate and no knowledge can be acquired without sensory information. The

[25] Dale H. Schunk, *Learning Theories: An Educational Perspective* (Upper Saddle River: Prentice-Hall Inc, 2000), 17.
[26] Dale H. Schunk, *Learning Theories: An Educational Perspective* (Upper Saddle River: Prentice-Hall Inc, 2000), 17.
[27] Dale H. Schunk, *Learning Theories: An Educational Perspective* (Upper Saddle River: Prentice-Hall Inc, 2000), 17.

accumulation of ideas precedes the formulation of more complex perceptions. Complicated concepts are usually comprised of a set of simple notions and can usually be traced to their origins.

Locke further postulated the existence of primary and secondary quality of objects. Primary qualities govern characteristics like size, shape, weight, and quantity. These qualities typically appear as objects in the surrounding environment. Secondary qualities entail color, sound, and taste. Early interaction with nature provides the widest range of primary qualities. Flora and fauna supply endless variations in shape, size, and weight. While close in comparison it should be noted that rarely will there be two objects in nature exactly alike. These similarities can trigger higher cognitive functions like memory, categorization, and association, qualities which may not be as easily obtained in a largely built environment. Secondary qualities are also more abundant in nature. A wider range of color gradients are observed in the natural environment as opposed to solid colors that dominate built objects. The natural world even boasts edible objects whereas food is only available at grocery stores, food establishments, and restaurants in an urban setting. An individual's ability to perceive these qualities is based on the developmental state of sensory receptors and their intellect.[28] Locke's contemporaries would go on to elaborate on the effects of primary and secondary qualities.

Notable empiricists such as George Berkeley (1685-1753), David Hume (1711-1776), and John Stuart Mill (1806-1873) contemplated Locke's theories and adapted them to suit their individual views. Berkeley felt reality existed entirely in the mind. His view held that only secondary qualities exist and there was no such thing as primary qualities. Berkeley was convinced ideas are based on experiences and people tend to impose those notions onto new sensory impressions.

Hume theorized individuals can never be certain about the external environment since it is perceived through preconceived notions based on past experiences. These ideas are

[28] Dale H. Schunk, *Learning Theories: An Educational Perspective* (Upper Saddle River: Prentice-Hall Inc, 2000), 17.

interpreted as reality though they may not fully reflect external conditions. Hume conceded that ideals are based on previous experience, and over time, are associated with similar concepts.

Mill, while considered an empiricist, rejected one of the major tenets of his school of thought. He disagreed with the concept of simple ideas combine in orderly ways to formulate complex ones. Mill believed simple notions led to the generation of complex theories but did not necessarily need to be comprised of, or include, the original idea. Mill's line of thinking contributes to the belief of the whole is greater than the sum of its parts.[29]

Traditional learning theories were steeped in thought and contemplation. Rationalism focused on reflection and critical thinking as the main means of ascertaining knowledge. Rationalism believed individuals could achieve higher means of thinking simply through pondering and meditation. Once empiricism appeared, accumulation of knowledge shifted to emphasize the importance of interaction with the surrounding environment. Noting the differences between available stimuli in natural and built environments demonstrates the importance of human-nature interaction. Sensory input from the external world was attributed with idea generation and formulation of complex notions. The significance of environmental stimuli increased as contemporary thinkers contributed to the emerging ideology. While many of their views differed on the formation of ideas, the importance of interactions with the surroundings never faltered.

3.3 CONTEMPORARY EDUCATIONAL THEORY

The means by which children learn are based on numerous reoccurring theories. Those mentioned below have the potential to benefit the most from contact with the natural environment. They include *cognitive, functionalist, behavioral,* and *constructivist* views. Each premise gives credence to the importance of the learning aptitude of an individual and the surrounding environment. There are two major factors that affect educational

[29] Dale H. Schunk, *Learning Theories: An Educational Perspective* (Upper Saddle River: Prentice-Hall Inc, 2000), 18.

theories. The first is *prior reinforcement history* and it governs previous discipline or praise meted out during past experiences. While reinforcement plays a critical role in development, parents should not strictly control every action a child undertakes. It is important for kids to have a certain amount of exploratory play without the expectation of disciplinary ramifications. The second factor is *developmental status* and it entails the capability of each individual given their present state of mental and physical development.[30] Even among children of the same age developmental status can differ greatly depending on their lifestyles. Mental deficiencies can prevent children from learning complex skills while physical shortcomings can result in slower acquisition of motor reflexes.

COGNITIVE THEORIES

Cognitive theories acknowledge the importance of environmental conditions, but typically view these factors as sources of input. Teacher's lectures, textbooks, and instructional demonstrations are considered among the most valuable sources of information. Combined with consistent practice and constructive feedback, a child can learn effectively. Cognitive theories extend well beyond environmental stimuli and examine how children retain, retrieve, catalogue, apply, and memorize information.[31] A child's thoughts, beliefs, and values play a significant role in the success of cognitive development. Kids who attend to lessons half-heartedly or hold expectations of failure will not learn as effectively as those who harbor attentive habits and self-confidence. Though it is easy to conceive cognitive theories as taking place in classrooms and educational institutions, the learning process will start well before a child is enrolled in school.

Memory, in regards to cognitive theories, governs information processing. It examines a child's ability to interpret, catalogue, and organize knowledge in a meaningful fashion.

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[30] Dale H. Schunk, *Learning Theories: An Educational Perspective* (Upper Saddle River: Prentice-Hall Inc, 2000), 12.
[31] Dale H. Schunk, *Learning Theories: An Educational Perspective* (Upper Saddle River: Prentice-Hall Inc, 2000), 12.

In cognitive theories, information is accessed based on cues that spur relevant memories. Forgetfulness is thereby described as the loss of memory, interference, or the absence of proper cues.[32] Memory plays a critical role in cognitive theories and determines the amount of information that can be retained by an individual.

Motivation and learning is considered similar but independent factors. Motivation is largely affected by reinforcement history. Children will often exhibit a certain type of behavior based on the expected outcome. A child praised for doing chores will do so again with the anticipation of similar, positive reinforcement. Conversely, a child may display in unfavorable behavior, even knowing they will be disciplined, if at the expense of annoying a sibling. When reinforcement history conflicts with current beliefs, a child will most likely act on their beliefs.[33] Cognitive theories acknowledge other sources of motivation such as goals, social conformity, or expression of individuality. Behavioral theories do not consider such cognitive functions and therefore cannot account for motivation as accurately.

Cognitive theories may seem pertinent to educational institutions and learning centers, but they can also benefit greatly from interaction with the natural environment. As discussed later, exposure to nature can help to increase memory capacity, hierarchical ordering, attentiveness, and creativity. Though information presented is not in the form of text or words, natural surroundings provide a plethora of learning stimuli in the form of sights, sounds, smells, textures, and even tastes. Children will benefit from early experiences with nature since their learning is largely sensory based. Before they can form complex notions of world, youths must accumulate a large base of knowledge. Nature not only provides a wide range of stimuli but also supplies the means to understanding growth, age, and other natural processes.

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[32] Dale H. Schunk, *Learning Theories: An Educational Perspective* (Upper Saddle River: Prentice-Hall Inc, 2000), 13.
[33] Dale H. Schunk, *Learning Theories: An Educational Perspective* (Upper Saddle River: Prentice-Hall Inc, 2000), 13.

FUNCTIONALIST THEORIES

Functionalism examines the mental processes and behaviors of individuals which help them to adapt to their environment.[34] Noted psychologist William James (1842-1910) contributed greatly to the progression of functionalist theories.[35] James' line of thinking was based in empiricism and believed experience was the catalyst for examining thoughts. He also held that simple ideas are not the direct result of environmental input, but the product of abstract thought and study. This type of reasoning helped people adapt to the surrounding environment.

Functionalist views gave credence to two aspects: *stimulus* and *response*. An example of a stimulus-response situation is a child looking curiously at a flame reaches out to touch it, gets burned, and retracts the hand. The original stimulus presented was the flame. In response to the enticing light and flicker of the flame, the child reaches out. When the new stimulus of pain is experienced, the child's natural response was to pull the hand away. Functionalists have divided over these stimulus-response examinations since some view it as a series of individual experiences while others feel such scenarios are experienced as one seamless response.

Functionalist theories are excellent for examining the natural environment. The simplistic stimulus-response view capitalizes on the various stimuli presented in nature. Much like the fire scenario presented earlier, nature provides a broader range of hazards children can learn safety from. Caution is an important concept for children to obtain. While fear is typically viewed as a negative quality, it does have some merit in that individuals take careful consideration before acting. Children learn that some plants have thorns, various insects sting, and ocean currents can potentially be dangerous. These lessons also apply to larger situations as well. There have been many cases where people have flocked to beaches and shorelines in hopes of catching a glimpse of an incoming

[34] Edna Heidbreder, *Seven Psychologies* (New York: D. Appleton-Century Company, Inc, 1933), 202.
[35] Dale H. Schunk, *Learning Theories: An Educational Perspective* (Upper Saddle River: Prentice-Hall Inc, 2000), 20.

tidal wave only to be caught unaware and swept out to sea. Tragic incidences like these could have easily been avoided had the thrill-seekers erred on the side of caution.

While the previously mentioned example and explanation enforce caution and safety, functionalism depicts much more about child interaction with nature. Youths learn that bark is rough, leaves are smooth, and sap is sticky. They will learn to differentiate between desirable and undesirable stimuli. Sap and other tacky substances are quickly perceived as bothersome since it hinders a child's main means of interaction, tactile sensation.[36] Young kids will also learn to appreciate aesthetic prowess. Flowers, waterfalls, and sunsets all garner admiration from viewers.

The simplistic nature of functionalism also brought many professionals to question its credibility. Functionalist theories tried to describe too broad a range of experiences and could be applied to basically any situation. Eventually behavioral theories would evolve take precedence.

BEHAVIORAL THEORIES

Behavioral theories stress the role of the environment and focus on the type of stimuli presented. Dealings with these objects can be monitored and reinforcement, positive or negative, planned for different scenarios. Children can greatly benefit from exposure to nature since it offers the most diverse range of stimuli. A larger collection of colors, smells, and textures can be found in a natural environment compared to constructed surroundings of similar size. In the household, young children are often presented with toys of an educational nature and can include mobiles, building blocks, interactive books or displays, and caricature-like representations of everyday objects. While they are beneficial, most are relegated to primary colors, one or two material types, and often consist of simple geometric shapes. Interacting with nature provides organic shapes,

[36] Yi Fu Tuan, *Space and Place: The Perspective of Experience* (Minneapolis: University of Minnesota Press, 2005), 21.

numerous textures, and a broader range of colors to produce a near infinite combination of appearances that help improve memory, visual acuity, and imagination.

Memory, in regards to behavioral theories, is considered instinctive. A child learns habitual reactions based on past experiences. Unlike studying for an exam, where information is accessed, analyzed, and implemented, behavioral memory is reactionary and nearly instantaneous. Forgetfulness, in a behavioral sense, can be viewed as the stagnation of physical skills. A kid who learns a physical technique, such as playing a sport, will find it difficult to pick up again if not used for an extended period of time.

Motivation in behavioral theories is perceived as an increased probability of a response based on previous experiences with stimuli or prior reinforcement. Children intrinsically seek positive stimulation or praise and try to avoid negative reinforcement or being disciplined.[37] Behavioral conditioning can produce favorable responses based on effective reinforcement. Children can learn to choose a task, persist at it, and strive to succeed, all of which are behaviors. Needs and emotions are considered independent of motivated behavior.[38] Just because a child may not enjoy a task does not mean they will not complete it to the best of their ability if effective reinforcement has taught them strong motivational behavior. Behavior theories do not differentiate between motivation and learning. Instead, a uniform set of principles is used to explain all behavior.

Behavioral theories encourage strict conditioning of a child's behavior. Generally positive and negative reinforcement is meted out. When considering natural environments, it is sometimes best to maintain parental supervision, but with minimal intervention. It is important that kids be allowed to form their own concepts and opinions without being influenced by parents who may no longer value a human-nature connection. Children will learn to be more independent, develop a healthy sense of curiosity, and become risk-takers. Children willing to take risks are likelier to engage in a diverse range of activities and further advance their knowledge and experience. Too

[37] Dak Kopec, *Environmental Psychology for Design* (China: Fairchild Publications, 2006), 19.
[38] B.F. Skinner, *The Technology of Teaching* (New York: Appleton-Century-Crofts, 1968), 151.

much negative reinforcement could lead a child to resent their parents and to take no enjoyment from potential learning situations.

CONSTRUCTIVIST THEORIES

Constructivist theories differ in that they are subjective compared to behavioral and cognitive theories which are objective. Both the latter assert the external world is real and therefore the goal of instruction is to promote development of responses and knowledge that exist in the world.[39] Constructivism posits that individuals take in information and process it according to their own needs, dispositions, attitudes, beliefs, and feelings.[40] Instruction recognizes the importance of the environment, much like behavioral and cognitive theories, but stresses interaction between students and surroundings. Learning is based on context, therefore cognition is relevant to that context and instruction should take place in that setting.

Constructivists develop curriculum based on an individual learner's needs. Such a specific regimen by no means invalidates the need for feedback and practice, and in fact, constructivists laud a student's motivation to develop their own understanding of any subject matter presented. Cultivating a learner's curiosity creates a diverse range of knowledge structures and leads to more avenues for accumulating skills.

There are similarities with behavioral and cognitive theories. All three instances promote active involvement of students and use scenarios that will allow for the maximum amount of knowledge to be extracted. Constructivism differs in that it provides more flexibility within the learning process. Behavioral theories emphasize discipline and enforcement of a child's reaction to environmental stimuli. Cognitive theories focus on idea generation through informative procedures. Both utilize rather linear concepts of learning behavior, whereas constructivism points out that while a student will learn from a mentor, they are encouraged to explore different means of obtaining information on their own.

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[39] Dale H. Schunk, *Learning Theories: An Educational Perspective* (Upper Saddle River: Prentice-Hall Inc, 2000), 25.
[40] Dale H. Schunk, *Learning Theories: An Educational Perspective* (Upper Saddle River: Prentice-Hall Inc, 2000), 24.

Constructivist theories take advantage of natural surroundings since they stress the importance of interaction with the environment and promote an individual's willingness to learn outside of instructional sessions. The inclusion of natural environments can lead to increased self-esteem, independence, a better ability to cope with difficult situations, effectiveness, and a likelier chance to take risks. Better coping skills lead to enhanced responsibility, efficiency, organization, and perseverance. As these traits emerge, an individual will be more likely to take responsibility for their own learning experiences.

3.4 THEORY PROGRESSION AND COMMONALITIES

Traditional educational theories posited that knowledge could be gained by thought alone. As rationalism gave way to empiricism, the environment began to play a minor role. The environment could no longer be ignored and was believed to provide stimuli to provoke formulation of notions and concepts. As educational theories further evolved, the environment played a substantially larger role. Rather than being viewed as a generic source of input, various other factors such as the types of stimuli available to children, reinforcement meted out by parents, and a child's willingness to explore their surroundings were examined.

The increasing inclusion of environmental contexts demonstrate importance of a child's surroundings and the natural world emerged as the best setting to enhance present day educational theories. Natural surroundings provide a limitless amount of shapes, smells, sights, and textures that appeal to a child's sensory development. Nature also presents various opportunities to learn about processes like age, growth, death and decay, and seasonal or cyclical functions.

Though educational theories depict a diverse range of learning behaviors, they all have relevancy to natural environments. Cognitive theories apply factors such as hierarchical ordering, memory retention, and information processing and are therefore better suited to complicated tasks like critical thinking and problem solving. Functionalist theories pose a simple explanation for stimulus-response experiences, but were too generalized to be accepted as a dominant learning theory. Behavioral theories focus on child interaction

with stimuli and the responses developed through experience and reinforcement. These theories are better for analyzing simple learning processes or physical techniques that involve muscle memory. Constructivist theories, while vague at times, stress the importance of learner interaction with the environment and developing individual procedures for obtaining knowledge. While these theories may seem significantly different, they do share some similarities.

Regardless of educational view, certain factors are prevalent in all theories (Figure 1). The learning process is most effective if allowed to take place in phases and stages. Educational theories focus on an individual's aptitude in acquiring and modifying their knowledge, skills, strategies, beliefs, and behaviors.[41] Learning encompasses the capacity to change behavior, or behave in an appropriate manner, through practice or past experience. These theories provide a basis to evaluate environmental observations, which in turn can be analyzed and applied to further solidify educational practice.

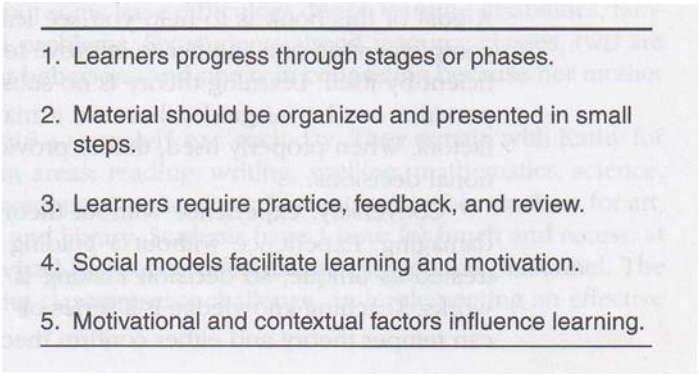
1. Learners progress through stages or phases.
2. Material should be organized and presented in small steps.
3. Learners require practice, feedback, and review.
4. Social models facilitate learning and motivation.
5. Motivational and contextual factors influence learning.

Figure 1: Common Principles of Educational Theories[42]

Occasionally such phases can be classified by an individual's competency and include novice, advanced beginner, competent, proficient, or expert. Instructors must incorporate their own system for determining the aptitude of a student, but once ascertained specific learning regimens can be devised. Tasks involved with such schemes can include speed

[41] Dale H. Schunk, *Learning Theories: An Educational Perspective* (Upper Saddle River: Prentice-Hall Inc, 2000), 29.
[42] Dale H. Schunk, *Learning Theories: An Educational Perspective* (Upper Saddle River: Prentice-Hall Inc, 2000), 25.

and typified cognitive processing, ability to recognize problem formats, proficiency in dealing with problems that arise, organization and depth of knowledge structures, and ability to monitor performance and select strategies depending on personal and contextual factors.[43] All three views will also benefit if a child displays attention, effort, and perseverance. Playing basketball and solving mathematical equations employ behavioral and cognitive theories respectively, but children can excel at either task equally effectively if they work hard. Successful learning, in either theory, also depends on setting goals, self-motivation, and monitoring of progress.

Educational theories often involve the organization of material, presentation of information in manageable quantities, opportunities for ample practice, provision of corrective feedback, and scheduling of review sessions.[44] Practice is possible the most valuable tool in skill development. Repetitious utilization of skills should not be undertaken to maintain current performance but should aim to improve and promote further progress. Such strides are complemented if parents also invest in a child's development by making time available, providing transportation to and from events, and handling financial obligations. Parents must provide support to encourage children to spend time practicing desirable skills. Parents should serve as good examples by cultivating their own proficiencies through practice.

[43] Dale H. Schunk, *Learning Theories: An Educational Perspective* (Upper Saddle River: Prentice-Hall Inc, 2000), 25.
[44] Dale H. Schunk, *Learning Theories: An Educational Perspective* (Upper Saddle River: Prentice-Hall Inc, 2000), 26.

4.0 TRANSFER

Once children acquire certain skills, it is up to them to use them in the appropriate situation, or to innovatively apply them to other tasks. *Transfer* refers knowledge and skills applied to situations of different circumstances from which they were learned. It also governs the effect of prior learning experiences on new ones. Previous learning can encourage, hinder, or have no effect on new aptitudes.[45] Transfer is invaluable to the learning process or all educational experience would be situational specific.

Natural environments, including green walls, have the potential to trigger various types of transfer. The natural world involves many of the academic processes students will learn about in biology, botany, horticulture, and chemistry and can even extend to mathematics, engineering, and physics. While learning about these subjects at an educational institution, students are limited to singular subjects. Immersed in natural environments, students can begin to grasp the interrelationships between subject matters and how they apply to the working world. No other setting can offer the diversity that is found in nature.

There are three levels of transfer: *positive*, *negative*, and *zero*. Positive transfer reflects prior learning facilitating subsequent acquisition of skill. New proficiencies can be of a more complex or simplistic nature. Having a good understanding of mathematics can aid in learning physics. Similarly, a mathematics background can help transition into other subjects like accounting, which is predominantly simple addition and subtraction with economic principles involved. Negative transfer occurs when prior education hinders the ability to obtain new proficiencies. A mathematic understanding may hinder the learning of physics once scientific principles begin to dictate formulas. Zero transfer depicts situations where prior learning does not affect subsequent learning. Mathematics will not facilitate learning to type on a keyboard. In most cases, zero transfer is due to the material at hand being of completely different natures, but in some circumstances, it

[45] Dale H. Schunk, *Learning Theories: An Educational Perspective* (Upper Saddle River: Prentice-Hall Inc, 2000), 14.

could be attributed to an individual's failure to comprehend the ramifications of applying previously learned conditioning.

There are several influences that affect transfer. Behavioral theories believe transfer occurs based on *identical elements* or similar features among situations. Transfer occurs much easier if there is a direct relation between the original and transfer task.[46] Furthermore, a direct link between tasks may exist, but students must be the one to recognize it or transfer will fail.

Mental discipline is also relevant to transfer. It holds that learning certain subject matter enhances general mental functioning better than other subjects.[47] Core subjects such as mathematics, sciences, and writing are thought to escalate the accumulation of knowledge in other areas. Mental discipline is very dependent on an individual's own aptitude for learning. Students with a higher intellect will find obtaining knowledge easier and therefore more readily achieve transfer.

Generalization encompasses responses from one discriminative stimulus to another.[48] A student is conditioned to pay attention in class, do homework, and behave appropriately. This is a generalization that applies to any class regardless of subject matter and even pertains to extracurricular activities. Generalization, just like identical elements, does have some shortcomings. Many factors from different situations may be similar, but individuals may choose to disregard some while elevating others based on cognitive assessment. Students are expected to be attentive in class but that my change if they are sick or distracted by external forces.

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[46] Dale H. Schunk, *Learning Theories: An Educational Perspective* (Upper Saddle River: Prentice-Hall Inc, 2000), 206.
[47] Dale H. Schunk, *Learning Theories: An Educational Perspective* (Upper Saddle River: Prentice-Hall Inc, 2000), 207.
[48] Dale H. Schunk, *Learning Theories: An Educational Perspective* (Upper Saddle River: Prentice-Hall Inc, 2000), 207.

4.1 TYPES OF TRANSFER

While the level of transfer is dictated with three general categories (positive, negative, and zero) actual types of transfer are much more complex. Most types of transfer appear as dualities, for example, *near* and *far*. These dualities are outlined in Table 4. Near transfer depicts situations where there is a great deal of overlap between stimuli presented, instruction, and environment. Far transfer involves learning scenarios that differ significantly from the original learning conditions.[49] If a student learns about biology an example of near transfer would be to take a test on the same subject matter in the same classroom it was originally taught. An example of far transfer would be if the student takes biological principles like photosynthesis and contemplates how the process facilitates plant growth and how they will observe it in the everyday world forthwith. The student will better comprehend why two plants of the same type may experience different growth rates when exposed to varying light conditions.

Type	Characteristics
Near	Much overlap between situations; original and transfer contexts are highly similar.
Far	Little overlap between situations; original and transfer contexts are dissimilar.
Literal	Intact skill or knowledge transfers to a new task.
Figural	Use of some aspects of general knowledge to think or learn about a problem, such as with analogies or metaphors.
Low road	Transfer of well-established skills in spontaneous and possibly automatic fashion.
High road	Transfer involving abstraction through explicit conscious formulation of connections between situations.
Forward reaching	Abstracting behavior and cognitions from the learning context to one or more potential transfer contexts.
Backward reaching	Abstracting in the transfer context features of the situation that allow for integration with previously learned skills and knowledge.

Table 4: Types of Transfer[50]

[49] Dale H. Schunk, *Learning Theories: An Educational Perspective* (Upper Saddle River: Prentice-Hall Inc, 2000), 208.
[50] Dale H. Schunk, *Learning Theories: An Educational Perspective* (Upper Saddle River: Prentice-Hall Inc, 2000), 209.

The next types of transfer are *literal* and *figural*. Literal transfer entails utilization of intact skills or knowledge to perform new tasks. Knowledge learned and applied in one situation is directly applied to others. An example of literal knowledge is a student hiking may view plants and vegetation growing on vertical surfaces such as cliffs and outcroppings. Further examination reveals that plant-life does not necessarily need soil as a medium, but only requires light, nutrients, water, and a surface for roots to spread. These principles can be applied to any other plant-rearing situation. Figural transfer refers to instances where only a portion of previously obtained knowledge is employed. This type of transfer typically uses analogies, metaphors, or comparable situations.[51] An example of figural transfer is recollection of the previously mentioned observations of plant growth and applying them to man-made components such as green walls and vertical gardens. A child will also comprehend how plants can exist in cracks of concrete or masonry buildings, rain gutters, or other settings where plant-life is not typically thought to grow. Figural transfer occurs when new learning material is encountered and old strategies from previous experiences are used.

The next duality is *low-road* and *high-road* transfer. Low-road transfer describes the transition of well established skills to spontaneous or automatic responses. Low-road transfer occurs with skills and actions that have been practiced extensively and an individual has achieved superior proficiency. These types of behaviors are often reactionary responses in situations with similar conditions in which they were obtained. Swimming is often a desirable skill for children to learn. It promotes safety as well as physical health. Once gaining a certain mastery of the aquatic sport, an individual instinctively treads water to keep his or her head above water and uses various swimming techniques to achieve mobility. Swimming is typically taught in pools at community centers, schools, or similar facilities. These skills are easily transferred to ponds, swimming holes, and lakes, but transition to oceans, seas, and rivers generally entails high-road transfer.

[51] Dale H. Schunk, *Learning Theories: An Educational Perspective* (Upper Saddle River: Prentice-Hall Inc, 2000), 208.

High-road transfer utilizes abstract thinking to make connections between one situation and another. This type of transfer occurs when an individual in a learning situation abstracts a rule, principle, prototype, or schema to apply in a fashion other than originally learned.[52] High-road transfer does not occur automatically like its low-road counterpart. Students must make careful considerations before applying previously established notions in new experiences. Learning to swim in a pool applies to lakes and ponds because of the similarity between calm bodies of water. Swimming in an ocean or river encourages high-road transfer in that an individual must then consider currents, waves, reefs or rocks, and other potential elements that are different from the learning environment.

Within high-road transfer there are two sub-categories: *forward-reaching* and *backward-reaching* transfer. Forward-reaching transfer takes place when a student abstracts behavior and cognitions from a learning situation to potential transfer applications and questions for future material.[53] While learning about biology a student may ponder how it affects comprehension of plant mutations and utilizations of cross-pollination to invent new species. This type of thinking is crucial for memory retention since children will better comprehend the material by considering future applications. Forward-reaching transfer is very proactive, requires constant self-monitoring, and encourages students to explore content on their own. It is also advantageous if an individual has a lot of prior experiences in a broad range of subjects. Limited experience will prevent a student from successfully realizing the potential for transfer.

Backward-reaching transfer is exactly the opposite of forward-reaching. While placed in a new learning situation a student will reflect on past experiences to derive an answer. While working on a chemistry problem an individual might reflect on prior household experiences like the acidity of lemon juice, boiling point of water, or simple conversion of oxygen to carbon dioxide through respiration. Children who have difficulty obtaining

[52] Schunk, Dale H. *Learning Theories: An Educational Perspective.* (Upper Saddle River: Prentice-Hall Inc, 2000), 210
[53] Schunk, Dale H. *Learning Theories: An Educational Perspective.* (Upper Saddle River: Prentice-Hall Inc, 2000), 210

new skills are prone to utilizing backward-reaching techniques in order to find a similarly perplexing situation and how they reached a solution in that instance. Backward-reaching techniques can be detrimental since prior solutions may have been obtained by simply asking parents and peers or other means of easily obtaining the answer without much effort.

Although the types of transfer mentioned have some overlapping principles they types of knowledge they govern varies. Near and literal transfer involves declarative knowledge and mastery of basic skills. Far and figurative transfer deals with declarative, procedural, and conditional knowledge.[54] They dictate what knowledge would be appropriate given a particular situation. Low-road involves declarative knowledge while high-road uses production and conditional knowledge.

The benefits of natural environments to transfer make their inclusion in a child's life of the utmost importance. Natural surroundings will foster interdisciplinary connections and enhance a child's ability to accumulate knowledge. Unfortunately, for youths of the present day, contact with nature is an increasingly uncommon occurrence. Urban areas afford minimal opportunities to engage park spaces and natural settings. New developments typically overlook implementation of green space in favor of more buildable lots. The realization for parks and other natural surroundings was made early on, but not many design guidelines have been enacted.

[54] Schunk, Dale H. *Learning Theories: An Educational Perspective.* (Upper Saddle River: Prentice-Hall Inc, 2000), 208

5.0 REALIZATION FOR NATURE TO CONTRAST WITH URBAN AREAS

As early as the 1870s and 1880s, urban life has been viewed with skepticism. As populations shifted from rural agricultural areas to developing hubs concern grew over activities affiliated with metropolitan areas. Drinking, gambling, and prostitution were commonplace and it adversely affected the urban atmosphere. Large cities were viewed as immoral, cold, and indifferent. The fast-paced urban lifestyle coupled with a monotonous and repetitive daily grinds led to a psychological disorder called "neurasthenia," or as it is more commonly known, "Worry: Disease of the Age."[55]

Positive reactions to nature were reinforced with the increase of industrialization. The therapeutic qualities the natural world were quickly realized. Nature-related activities were highly coveted for their regenerative and stress-reducing effects. City dwellers often traveled for hours on the weekend to reach premiere destinations characterized by lush forests, pristine lakes, and rolling mountains. Indeed, these types of activities are often enjoyed by families and serve to strengthen relationships and communication.

Children in urban, and increasingly suburban environments, face many obstacles that prevent them from interacting with nature. Exposure to nature is crucial during the early stages of development since a child's learning capacities are primarily based on sensory perception. It is safe to assume that all children are born with an affinity to nature, but it could easily be overlooked if raised by parents who, over time, have lost their own need to maintain a human-nature connection. Schools may not be providing natural environments for children, a time when their education promotes knowledge of the working world, and when children are exceptionally open-minded.[56] Residential neighborhoods may also lack opportunities for children to engage nature. Parks may be

[55] Sharon Wall, *The Nurture of Nature: Childhood, Antimodernism, and Ontario Summer Camps, 1920-55* (Vancouver: UBC Press, 2009), 6.
[56] Robin C. Moore. and Clare C. Marcus, "Healthy Planet, Healthy Children: Designing Nature into the Daily Spaces of Childhood." In *Biophilic Design*, ed. by Stephen R. Kellert et al. (New Jersey: John Wiley & Sons, Inc., 2008), 155.

absent, but traffic and other divisions may prevent mobility and hinder the chance for exploration.

A study conducted on the island of Cyprus, in the Mediterranean Sea, found that children and adults had differing views regarding their needs and wants within the home. A child's preferences were more in line with suburban conditions and commonly included the desire for a lawn.[57] Further research in the United States has revealed that children, especially when young, spend the majority of their time at home.

The quality of housing can dramatically affect psychological health and task persistence. Poor quality housing leads a child to believe they have a limited amount of control over their environment and can lead to a sense of helplessness. Children living in higher quality housing tend to have fewer behavioral problems, lower incidences of anxiety, depression, misconduct, and often score higher on tests designed to measure personal motivation.[58] Higher quality housing has increasingly been found to have open space to encourage outdoor play. Outdoor areas allow for activities that may not be permissible indoors such as water play, construction, sandboxes, gardening, climbing, swinging, and riding wheeled toys.[59] Natural environments aid considerably in restoring mental and physical health in housing situations.

There is growing concern over youth in today's society being highly susceptible to consumer culture. With new electronics such as cell phones, computers, handheld gaming systems, and electronic tablets being released almost monthly, younger generations are sinking large portions of their leisure time into electronic media. Parents, and older generations alike, are worried that youngsters will not learn to enjoy the simple enjoyments in life, the importance of physical exertion, and the ethic of hard work. Failure to grasp such concepts may prevent young children from developing into responsible, productive, and respectable adults.

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[57] Dak Kopec, *Environmental Psychology for Design* (China: Fairchild Publications, 2006), 149.
[58] Dak Kopec, *Environmental Psychology for Design* (China: Fairchild Publications, 2006), 149.
[59] Carol S. Weinstein and Thomas G. David, *Spaces for Children: The Built Environment and Childhood Development* (New York: Plenum Press, 1987), 154.

6.0 CHILDHOOD DEVELOPMENT

Exposure to natural environments is vital to childhood development. While children are less prone to infectious diseases or epidemics, present day society hosts a wide range of "lifestyle diseases" that have resulted from rapid, massive cultural changes.[60] With new advents in technology, rampant development, and a shift in parental concerns, more and more children spend majority of their time indoors, away from nature. Computers, gaming consoles, and social media are but a few of the technological changes occupying children and keeping them indoors.

Urban, and even suburban environments, have seen drastic decreases in the amount of park space and green areas available for child interaction. Parents also harbor increased anxiety regarding stranger-danger, increased traffic, and phantom health concerns. This lack of child-nature interaction can lead to attention deficiencies, valuing of material objects, shortcomings in emotional, physical, and intellectual growth, and occasionally illness. There are no inoculations or medications to remedy these "lifestyle diseases" and the only solution is to employ changes within the built environment.

The majority of children live in urban environments with approximately half of them living in areas hosting a population of 500,000 people or less.[61] It is crucial for children in these environments to have access to natural landscapes. The most beneficial places to implement natural amenities are schools, childcare centers, community facilities, and residential neighborhoods. Other, larger attractions such as botanical gardens, zoos, and museums are also highly desirable.

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[60] Robin C. Moore. and Clare C. Marcus, "Healthy Planet, Healthy Children: Designing Nature into the Daily Spaces of Childhood." In *Biophilic Design*, ed. by Stephen R. Kellert et al. (New Jersey: John Wiley & Sons, Inc., 2008), 153.

[61] Robin C. Moore. and Clare C. Marcus, "Healthy Planet, Healthy Children: Designing Nature into the Daily Spaces of Childhood." In *Biophilic Design*, ed. by Stephen R. Kellert et al. (New Jersey: John Wiley & Sons, Inc., 2008), 154.

6.1 TYPES OF EXPERIENCE

The most important time during an individual's development is during childhood. During these early years behaviors, mannerisms, and communication skills will form that will inevitably be exercised throughout a person's lifetime. Children learn through three major means of contact: direct, indirect, and symbolic experience. Each type provides a unique type of environmental interaction and young children should experience all three to ensure an optimal knowledge base.

Figure 2: Example of a Direct Experience in Nature[62]

Direct experience describes interaction with the natural environment, particularly areas that are undisturbed by human influence (Figure 2). If any human activity is involved it is usually in a minimal capacity and relegated only to small objects children may interact with like toys and props. The surrounding environment of animals, plants, and habitat appear in their natural state. These direct experiences are usually spontaneous and

[62] http://msnbcmedia.msn.com/j/MSNBC/Components/Photo/_new/120216-child%20in%20woods.photoblog500.jpg

unplanned and set in forests, rivers, and meadows.[63] This type of interaction is a great way for children to develop an understanding of dynamic environments. Changing seasons bring new colors, smells, and shapes, which are vital to the development of sensory capacities in young children. The growth of trees and vegetation can be observed and instill a sense of time and compassion for living things. Direct experience can also promote appreciation for the natural state of objects and inhibit the need to alter or control them.

Figure 3: Example of an Indirect Experience in Nature[64]

Indirect contact takes place in a controlled environment. These areas include zoos, botanical gardens, museums, and parks (Figure 3). Any indirect contact usually entails elements of a natural environment placed in a domesticated setting. These environments demonstrate mankind's manipulation and influence over nature. The vegetation in these areas are usually chosen for specific purposes, whether aesthetic or functional, and are carefully maintained. They can include potted plants, farm crops, or a neatly trimmed hedge acting as a divider. Animals are of a domesticated nature and can include dogs, cats, and can be extended to include farm animals. Other creatures such as aquarium fish

[63] Peter H. Kahn and Stephen R. Kellert, *Children and Nature: Psychological, Sociocultural, and Evolutionary Investigations* (Cambridge: The MIT Press, 2002), 119.
[64] http://graphics8.nytimes.com/images/2008/03/16/arts/16shat600.1.jpg

can be considered in this category though their behavioral patterns remain largely of their original nature. Most elements of indirect contact demonstrate human intervention or control.[65] These events are usually planned or organized events. Indirect contact provides a safe environment but still allows interaction with natural surroundings. Having domesticated plants and pets teaches children to care for other living objects and to emotionally invest in their growth and well-being.

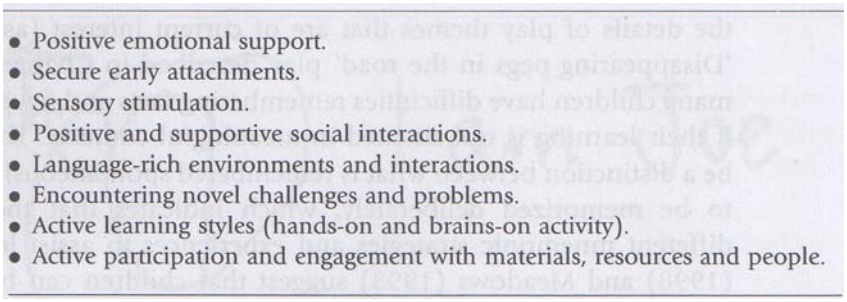
Figure 4: Example of a Symbolic Experience with Nature[66]

A symbolic, sometimes referred to as a vicarious experience, does not involve any physical contact. Instead it conveys a representation, metaphor, or image of nature.[67] These can include informative programs about nature, books, magazines, and even

[65] Peter H. Kahn and Stephen R. Kellert, *Children and Nature: Psychological, Sociocultural, and Evolutionary Investigations* (Cambridge: The MIT Press, 2002), 119.
[66] http://thekaleo.files.wordpress.com/2011/06/naturepainting.jpg
[67] Stephen R. Kellert, *Building for Life: Designing and Understanding the Human-Nature Connection* (Washington D.C.: Island Press, 2005), 65-66.

cartoons involving a natural backdrop (Figure 4). These replications of the natural environment may be skewed due to a cartoonist's style or modern media, but nonetheless they are still a type of exposure. Contemporary media, which is much easier to access with current trends in technology, consist of television, films, and internet sites. These pictorial representations of nature still have educational benefit, but as always, actual physical contact will net the most experiential gains.

Regardless of the type of experience, observation of a child's development is critical. It is important for parents to monitor accumulation of knowledge and understanding, how a child makes judgments and interpretations, analyzes relationships, and provide reinforcement.[68] Also independent of the type of experience, any situation must provide certain qualities to promote growth and development (Figure 5).



- Positive emotional support.
- Secure early attachments.
- Sensory stimulation.
- Positive and supportive social interactions.
- Language-rich environments and interactions.
- Encountering novel challenges and problems.
- Active learning styles (hands-on and brains-on activity).
- Active participation and engagement with materials, resources and people.

Figure 5: Common Qualities Any Environment Should Contain to Promote Growth and Development[69]

One concern for today's children is that the overwhelming popularity of television and the internet is leading to a steep decline in direct exposure to nature. This is a major concern among urban and suburban areas where children may already have a limited opportunity to interact with natural environments. Family vacations are increasingly taken to theme parks and other attractions rather than camping or other outdoor activities. This decline in contact with the natural world does not provide the maximal nurturing environment. While attractions can instill an appreciation for relaxation, entertainment,

[68] Elizabeth Wood and Jane Attfield, *Play, Learning, and the Early Childhood Curriculum* (Thousand Oaks: SAGE Publications, Inc., 2005), 184-185.
[69] Elizabeth Wood and Jane Attfield, *Play, Learning, and the Early Childhood Curriculum* (Thousand Oaks: SAGE Publications, Inc., 2005), 68.

and adventure, they cannot offer the same range of smells, sights, and textures found in nature that are critical to childhood development.

COGNITIVE DEVELOPMENT

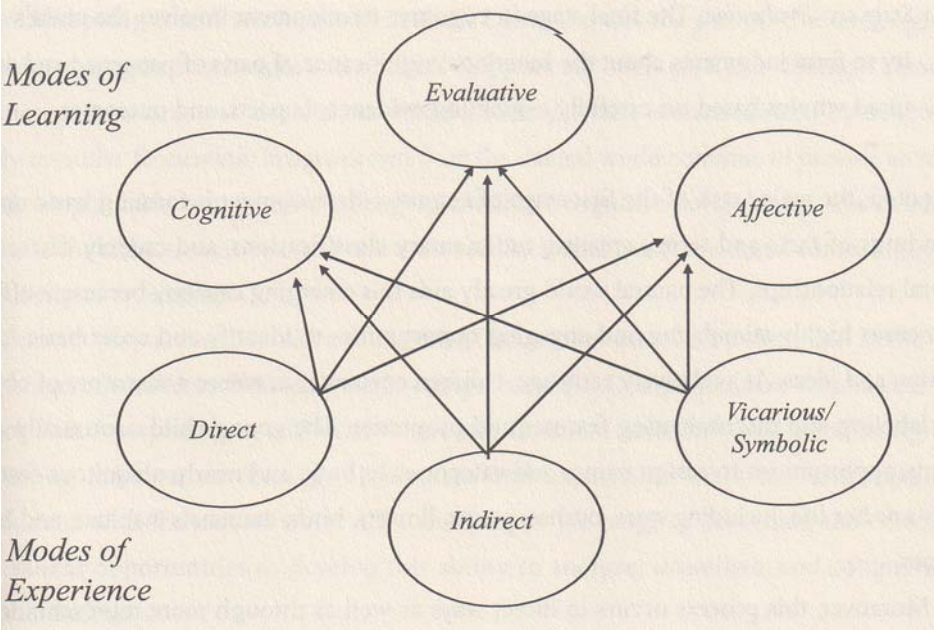


Figure 6: Relationships Between Modes of Learning and Modes of Experience

Childhood growth depends on three different areas: cognitive, affective, and evaluative development. These areas are of development each share relationships with the different types of experience (Figure 6). Cognitive development governs problem solving, understanding, and critical thinking. As described by psychologist Benjamin Bloom, it occurs in six stages.[70] They range from simplistic to complex in a increasingly complex order. The first stage is *knowledge* and promotes a basic understanding of facts and terms and how to apply them in presenting ideas and understanding relationships. The accumulation of knowledge aids in creating hierarchical ordering, classifications, and establishing causal connections.[71] The second stage is *comprehension* and involves

[70] Stephen R. Kellert, *Building for Life: Designing and Understanding the Human-Nature Connection* (Washington D.C.: Island Press, 2005), 67.
[71] Peter H. Kahn and Stephen R. Kellert, *Children and Nature: Psychological, Sociocultural, and Evolutionary Investigations* (Cambridge: The MIT Press, 2002), 121.

interpreting information and ideas and then to apply that understanding to new situations. The third stage is *application* and encourages using accumulated knowledge to develop ideas, concepts, and expectations to various situations. The fourth phase is *analysis* and describes a child's ability to break down knowledge into constituent parts and to then grasp the meaning of each area. The fifth stage is *synthesis* and portrays a child's aptitude for turning bits of knowledge into a greater understanding of the whole. A child starts to comprehend relationships and their interdependencies. The sixth and final stage is *evaluation* and elicits judgments regarding all the knowledge obtained and then to recognize patterns and structures.

Direct contact with nature can have a significant impact on cognitive development. Children can especially benefit from direct exposure during middle childhood and early adolescence. This is critically important for the *knowledge* portion of the learning process. It will help young individuals generate classification systems, categories, and identifying relationships between entities. These will ultimately lead to greater information retention and memory capacity.[72] Children will be able to discern the slight differences between similar items, begin labeling and naming, and recognizing similar features and behaviors between organisms. The more diverse the range of exposure a child gets, the better their ability will be to discern differences over a broader range of categories.

Symbolic experience also has a benefit to cognitive development but can often go overlooked. Many books created for preschoolers and young children alike draw their imagery from nature. A lot of characters are based on animals and these stories encourage naming, ordering, and counting among other valuable skills.[73] Alphabetical or numerical books often utilize animals as placeholders. Many famous books series like the *Berenstain Bears* or *Clifford the Big Red Dog* utilized animal representations as the main characters rather than human figures. Anthropologist Elizabeth Lawrence coined

[72] Peter H. Kahn and Stephen R. Kellert, *Children and Nature: Psychological, Sociocultural, and Evolutionary Investigations* (Cambridge: The MIT Press, 2002), 122-123.
[73] Peter H. Kahn and Stephen R. Kellert, *Children and Nature: Psychological, Sociocultural, and Evolutionary Investigations* (Cambridge: The MIT Press, 2002), 121.

the term "cognitive biophilia" as a way to refer to symbols and images of nature that promote intellectual development.[74] Larger urban areas find that children must rely heavily on indirect and symbolic experiences to enhance cognitive development. There are sparse opportunities for direct contact in backyards, parks, and even some streetscapes, but for the most part, zoos, museums, arboretums, and school programs will be the main source for cognitive advancement.

AFFECTIVE DEVELOPMENT

Affective development entails emotional maturation. Psychologist David Krathwohl has identified five stages that affective growth covers.[75] The first stage is *receiving*, which focuses on awareness of information or ideas and the willingness to accept and contemplate them. Stage two is *responding* and involves the capacity to react to, and in some cases, gain satisfaction from receiving information. The third stage is *valuing* and aids in determining the worth of information and applying the same value system to all types received. Stage four is *organization* and encourages the formation of preferences in determining worth of information and translating them into systematic beliefs. The fifth and final stage is *characterization by a value or complex value* and emphasizes the creation of a philosophy of life based on the previous steps.

The most important aspect of affective development is the ability of a young individual to shape values. These values are a combination of emotional and intellectual qualities and cannot be classified as one or the other, but more of a hybrid between the two. The first stage of *receiving* is vital to a child's value formation. Their attitude towards nature affects the rate at which they receive natural stimuli, and their emotional state dictates the amount of exposure. A child may be attracted to nature, curious, excited, or adventurous, conversely, they could dislike nature, display boredom, fear, or indifference. Emotions towards nature are often shaped by a child's immediate contacts such as parents, siblings,

[74] Peter H. Kahn and Stephen R. Kellert, *Children and Nature: Psychological, Sociocultural, and Evolutionary Investigations* (Cambridge: The MIT Press, 2002), 121.
[75] Stephen R. Kellert, *Building for Life: Designing and Understanding the Human-Nature Connection* (Washington D.C.: Island Press, 2005), 70.

teachers, and peers. It is important that they develop an affinity for the natural world during middle childhood since it is a key point in developing emotional responsiveness and receptivity.

A study by Edith Cobb demonstrated that the fondest memories of most adults involved situations that took place in a natural environment.[76] She further concluded that a child's sense of nature is almost purely aesthetic and leads them to feel the necessity for creation. Cobb suggested that the innumerate variances encountered in nature nurture a young individual's creativity, appreciation for beauty, and sense of identity. Environmental scientist Rachel Carson discovered children take great joy in experiencing nature. Their interactions promote enthusiasm for all things natural and a passion for life in all forms. Both values are essential for personality formation.[77]

While nature can instill emotions of splendor, joy, wonder, and curiosity, it can also produce fear and anxiety. While seemingly negative emotions to evoke, they are nonetheless necessary in holistic development. By engaging their natural surroundings children will learn to recognize potential dangers. Harmful animals or insects, hazardous water conditions, poisonous plants, and even unsafe weather conditions will become distinguishable. As these skills develop even the difference between edible plants may also be discernable. Identifying these types of situations as soon as possible is crucial in determining an appropriate response for avoidance, or at least, mitigation. As recognition becomes second nature, so too will conditioned reactions. In the home, children will learn to recognize that scissors are sharp, electrical outlets dangerous, and small objects are choking hazards. While these are good to know, they are a completely separate set of possible threats from the natural environment.

Nature is valuable to affective development most conditions found in nature cannot be replicated and are only observed in nature. Contact with nature is often linear since it is

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[76] Peter H. Kahn and Stephen R. Kellert, *Children and Nature: Psychological, Sociocultural, and Evolutionary Investigations* (Cambridge: The MIT Press, 2002), 127.
[77] Peter H. Kahn and Stephen R. Kellert, *Children and Nature: Psychological, Sociocultural, and Evolutionary Investigations* (Cambridge: The MIT Press, 2002), 129.

not obscured by human relationships. In this way they remain stable and constant unlike when human intervention may impose emotions, biases, and preconceived notions.

EVALUATIVE DEVELOPMENT

The last type of development is evaluative. It describes a child's ability to form values and adjusting them as necessary.[78] Evaluative development encompasses the nine values of biophilia, to be discussed later. Adequate exposure is imperative for proper development of these biophilic tenets. Failure to experience nature could result in a stunted intellect, limited imagination, unease in natural environments, and an inability to make realistic assumptions. While applicable to all environments in life, these values, for these purposes, are projected onto nature and mankind's natural affinity for it. They can also be influenced strictly by nature but may also take into consideration culture, learning, and other experiences.

[78] Stephen R. Kellert, *Building for Life: Designing and Understanding the Human-Nature Connection* (Washington D.C.: Island Press, 2005), 72.

7.0 THE NINE VALUES OF BIOPHILIA

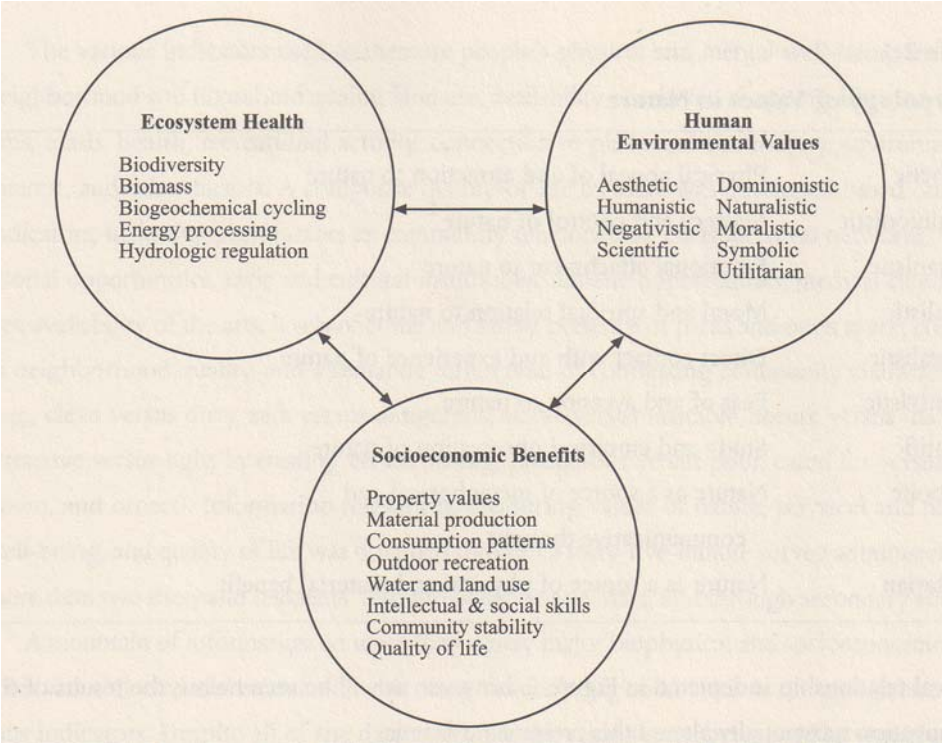

Figure 7: The Relationship Between Values of Biophilia, Ecosystem Health, and Socioeconomic Benefits[79]

The understanding and innate appreciation for nature that stems from biophilia can be broken down into nine different values. These principles affect our interpretation and interaction with the environment. They also help to better understand the interrelationship between the values, ecosystem health, and socioeconomic benefits (Figure 7). A lack of exposure to nature can hinder the proper development in an individual and often leads to physical, emotional, or intellectual shortcomings. However, if an individual receives an adequate amount of experience with nature to stimulate all the different values they are more likely to develop critical thinking and problem solving skills, creativity, an explorative and inquisitive demeanor, expression of affection, and promoting social

[79] Stephen R. Kellert, *Building for Life: Designing and Understanding the Human-Nature Connection* (Washington D.C.: Island Press, 2005), 33.

ties.[80] These values are aesthetic, dominionistic, humanistic, moralistic, naturalistic, negativistic, scientific, symbolic, and utilitarian (Table 5).

Aesthetic	Physical appeal of and attraction to nature
Dominionistic	Mastery and control of nature
Humanistic	Emotional attachment to nature
Moralistic	Moral and spiritual relation to nature
Naturalistic	Direct contact with and experience of nature
Negativistic	Fear of and aversion to nature
Scientific	Study and empirical observation of nature
Symbolic	Nature as a source of metaphorical and communicative thought
Utilitarian	Nature as a source of physical and material benefit

Table 5: Values of Biophilia[81]

Utilitarian refers to a reliance on nature for materials and commodities. Positive traits attributed to this view are physical and material security, self-confidence and self-esteem through demonstrating skill in nature, and recognition of mankind's dependency on the natural world for resources. Nature is the source for agricultural, medicinal, and industrial items.

A *dominionistic* view expresses the urge to exert control over the natural world. By demonstrating power over the natural environment, mankind displays the ability to overcome obstacles and deal with hardship. This value instills safety, protection, and independence. It also leads young individuals to become risk-takers and a willingness to confront the unknown.

A *naturalistic* view deems nature as source for stimulation, entertainment, and diversity. This view encourages exploration and discovery and recognizes that the natural

[80] Stephen R. Kellert, *Building for Life: Designing and Understanding the Human-Nature Connection* (Washington D.C.: Island Press, 2005), 50.
[81] Stephen R. Kellert, *Building for Life: Designing and Understanding the Human-Nature Connection* (Washington D.C.: Island Press, 2005), 34.

environment represents an infinite amount for both. It often enforces total immersion into a natural environment. Children accustomed to this gain a sense of discovery, curiosity, inquisitiveness, and imagination. Their self-confidence and self-esteem are also enhanced through adaptation to shifting natural conditions and coping with difficult situations.

A *scientific* view deals with nature as a source for knowledge and intellectual stimulation. This outlook dictates methodically studying the surroundings and striving to fully understand it. This value helps young individuals acquire intellectual prowess, critical thinking skills, and problem solving abilities. They also promote observation and analysis, which in turn creates an appreciation for natural occurrences and the diversity present in nature.

A *symbolic* view reflects the natural world as the basis for imagination and communication. Benefits include improved communication skills, relating to actual occurrences through story and fantasy, and understanding of symbolic representation. Most folklore and myths stem from some inspiration in nature and have been a means of communication since the earliest of civilizations. These myths and legends have often become the basis for many societies that thrived in the early times of mankind and could even be said to serve as the basis for some of their prominent religions.

An *aesthetic* view sees the natural world as a source of splendor and beauty. Analyzing nature can reveal much about balance, symmetry, and order. Children learn to recognize shape and form and place them into categories. This view encourages curiosity, imagination, and discovery. It also nurtures a healthy disposition towards exploration of the natural environment.

A *humanistic* value holds to the idea that nature is capable of evoking emotion and attachment. Children learn intimacy, companionship, and trust. This in turn leads an individual to become familiar with giving and receiving affection, forming social bonds, and other social regularities. It also helps to build self-confidence and self-esteem and allows kids to function better in group settings.

A *negativistic* view looks at harboring a fear of nature. This value helps children avoid injury, minimize risk, and recognize potentially harmful situations. A little bit of fear can be a healthy condition and invokes a sense of awe and respect for natural occurrences, but manifested too long, they can become phobias. Phobias are difficult to cope with since they are often beyond the means of reasoning and cannot be compensated through normal means of comfort.

Finally, a *moralistic* value turns to nature as a source of moral and spiritual motivation. Nature is the ultimate sign of creation and from creation stems divine intervention for some. Benefits include gaining a sense of underlying meaning, order, and purpose. A moralistic view may also contribute to greater sociability by sharing the same ideals and spiritual conviction as others. A reverence of nature can prove beneficial since it often leads to preservative measures.[82] Each value plays the part of a greater whole and as many should be engaged as possible to ensure a healthy upbringing.

7.1 DIFFERENT AGES, DIFFERENT STAGES

These values may emerge at different ages, but has the same incremental characteristics as cognitive and affective development. First, an individual's experiences and perceptions of nature are broken down to abstract levels of thinking. Second, the formation of values shifts from personal, egocentric concerns to broader ones concerned with social or group interests. Third, the values then grow larger from a local geographical setting to a regional or even global view. Lastly, emotional responses are usually generated before logical and reasoned perspectives.[83] The values of biophilia may arise at different ages, but once acquired, individuals don't particularly forget them, other ideals just take precedence.

The first development period occurs between the ages of three and six and typically sees the formation of utilitarian, dominionistic, and negativistic values. These views are

[82] Stephen R. Kellert, *Building for Life: Designing and Understanding the Human-Nature Connection* (Washington D.C.: Island Press, 2005), 51-57.
[83] Peter H. Kahn and Stephen R. Kellert, *Children and Nature: Psychological, Sociocultural, and Evolutionary Investigations* (Cambridge: The MIT Press, 2002), 132.

formed based on the child's need to fulfill their physical and material wants, feelings of security and comfort, and safety.[84] An appreciation for nature and consideration of other beings is usually subordinated by the child's own egocentric values of satisfying their own desires first. Often times a kid may display anxiety if exposed to too many sources of input. Exposing them to a limited amount of familiar objects in a domesticated setting is encouraged.

The second development period happens during middle childhood between six to twelve years of age. This stage likely witnesses the formation of humanistic, symbolic, scientific, and aesthetic values.[85] The three values previously learned, utilitarian, dominionistic, and negativistic, lessen in importance. By now, children are better acquainted with natural environments. However, they are more likely accustomed to their own backyard than they are to a truly natural setting. A child's exposure to the natural world piques their curiosity for nature and animals. They will begin to take responsibility for the care of their natural surroundings without having to be told. At this age they will more readily explore unknown natural areas, develop independence, and expand their knowledge of nature.

Independence is important because, during this stage in particular, young individuals will try to establish their identity. Children often want to tailor themselves in a fashion that sets them apart from their parents, the home setting, and other children. Using their natural environment to construct objects will impart creativity and self sufficiency. During the middle childhood years, children will often profess a need to build or create objects. This need to construct can often manifest in the forms of forts, dens, secret hiding places, or treehouses. Children will take great pride in successful transformation of the environment and the ability to create a place of comfort for themselves.[86]

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[84] Peter H. Kahn and Stephen R. Kellert, *Children and Nature: Psychological, Sociocultural, and Evolutionary Investigations* (Cambridge: The MIT Press, 2002), 132.
[85] Peter H. Kahn and Stephen R. Kellert, *Children and Nature: Psychological, Sociocultural, and Evolutionary Investigations* (Cambridge: The MIT Press, 2002), 133.
[86] Peter H. Kahn and Stephen R. Kellert, *Children and Nature: Psychological, Sociocultural, and Evolutionary Investigations* (Cambridge: The MIT Press, 2002), 134.

Direct contact is the best way to interact with nature at this stage, but it does not degrade the significance of indirect or symbolic experiences. Both are still invaluable in strengthening labeling, classification, and language acquisition. Children in the middle childhood range are often captivated by folk tales, legends, and myths based on characters from the natural world. These tales often have characters of heroic proportions and spin a tale of good triumphing over great evil usually at great cost to the surrounding landscape. While the depictions of the natural world may be a bit distorted, they still teach children about conflict, resolve, control, desire, and other issues.[87]

The third and last stage of development occurs in teens between thirteen and seventeen years of age. The largest gains are made in moralistic, naturalistic, and scientific values. During these years, individuals demonstrate a greater capacity to think conceptually, abstractly, and apply ethical reasoning to the natural surroundings. They can grasp larger concepts of ecology and evolutionary process, whereas prior to that, logic was applied on a much smaller scale. Thinking of the big picture helps adolescence make the connection between human activity and its effects on the natural world. This also inspires a respect for nature and a sense of responsibility for its well-being.

Most individuals in this age range also test the limits of the natural world through daring, challenging, and occasionally foolhardy endeavors. This is important for self-esteem, self-confidence, and a sense of identity. The easiest way for teenagers to accomplish this is to participate in sports or other outdoor activities which take place in a natural setting undisturbed by human influence. Cross country, trail running, regatta, and kayaking are just a few good examples.

Once the tenets of biophilia, different stages of learning, and types of development are all taken into consideration, the significance of nature in the growth and maturation of children is evident. The different types of experience will determine the degree to which young individuals benefit from enjoying nature. The importance of direct experiences

[87] Peter H. Kahn and Stephen R. Kellert, *Children and Nature: Psychological, Sociocultural, and Evolutionary Investigations* (Cambridge: The MIT Press, 2002), 135.

cannot be stressed enough. In no way does it degrade indirect of symbolic interaction, but it is by far the most significant. It is important to all age groups and stages of development. A study conducted by Rachel Seba found that regardless of age, gender, and ethnicity, 96.5% of all participants indicated that some form of outdoor environment proved to be the most significant during their childhood.[88] The prominent fondness for natural environments is due to the every changing stimuli presented in nature and the innumerous advantages it presents for children as they grow to adulthood. As these young individuals mature into adults, they will take with them the passion for the natural world. They will actively seek it out and promote its preservation. Such values of nature have been attributed to biophilia.

[88] Peter H. Kahn and Stephen R. Kellert, *Children and Nature: Psychological, Sociocultural, and Evolutionary Investigations* (Cambridge: The MIT Press, 2002), 135.

8.0 BETTER HEALTH AND WELL-BEING

It is a long held belief that parks and gardens provide a beneficial and regenerative environment. This idea can be reinforced through a pyramidal diagram that results with a better quality of life at the apex (Figure 8). They are great for rest and relaxation, recreation, and often have spiritual value. The almost divine quality of green spaces stem from ancient practices where serene forests or areas were often thought to house deities and other spiritual entities.[89] In Japan, such areas are marked by *torii*, gateways to indicate areas of perceived spiritual prowess. They are often set in tranquil mountains or scenic rivers and lakes. This respect for such natural beauty extends into the present day. Many national and state parks have been declared so in order to preserve their extraordinary splendor.

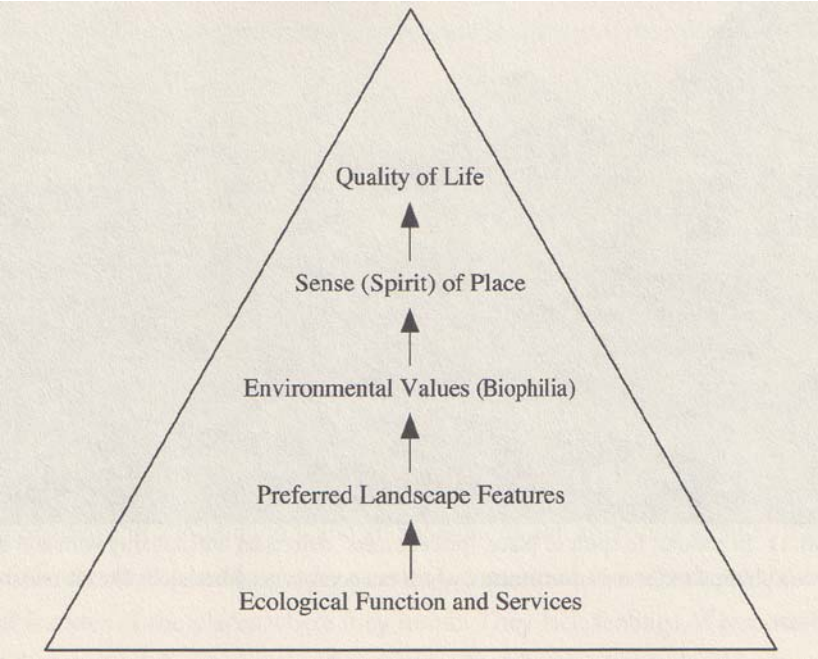


Figure 8: Pyramidal Diagram Displaying Benefits from the Inclusion of Nature[90]

[89] Stephen R. Kellert, *Building for Life: Designing and Understanding the Human-Nature Connection* (Washington D.C.: Island Press, 2005), 13.
[90] Stephen R. Kellert, *Building for Life: Designing and Understanding the Human-Nature Connection* (Washington D.C.: Island Press, 2005), 62.

Though the reverence for such natural magnificence has long been acknowledge, studies of their beneficial effects are a more recent endeavor. Along with visual stimulation, park-like spaces reduce stress, increase tranquility, improve demeanor, enhance physical fitness, and leads to greater creativity. Several investigations have even shown physiological impacts such as lower blood pressure and decreased muscle tension when comparing individuals in different environments (Figure 9).[91] Natural surroundings provide a near limitless number of scenarios that can improve physical, mental, emotional, and social health and promote better childhood development in general. Much of the research and studies discussed will have an impact on numerous aspects of health.

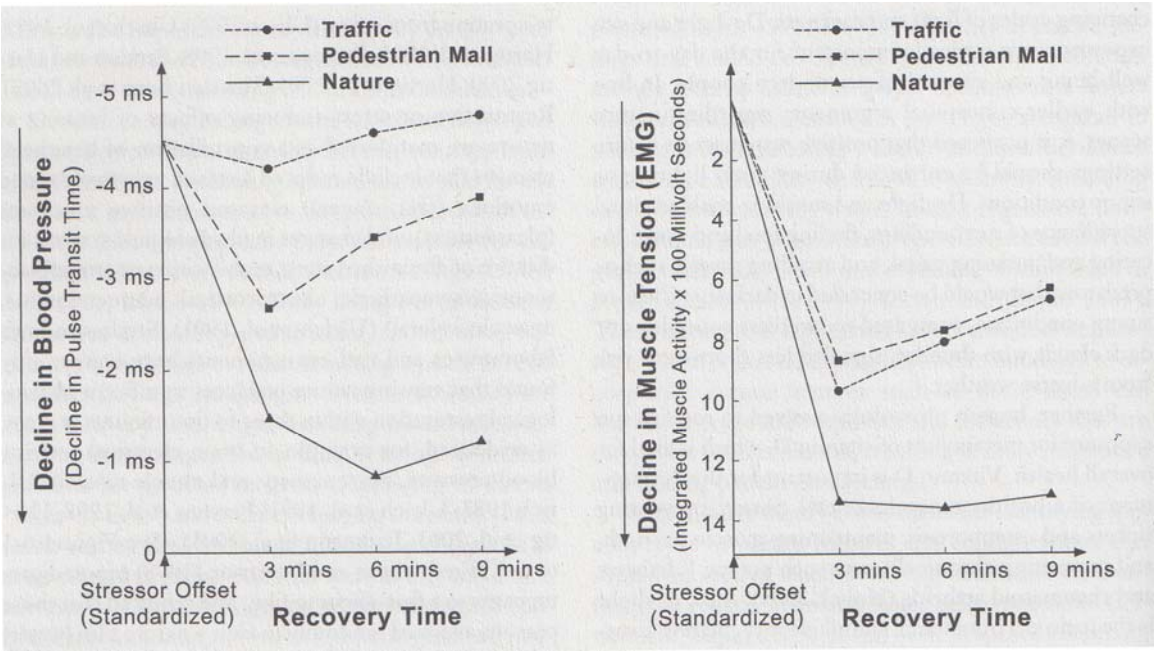
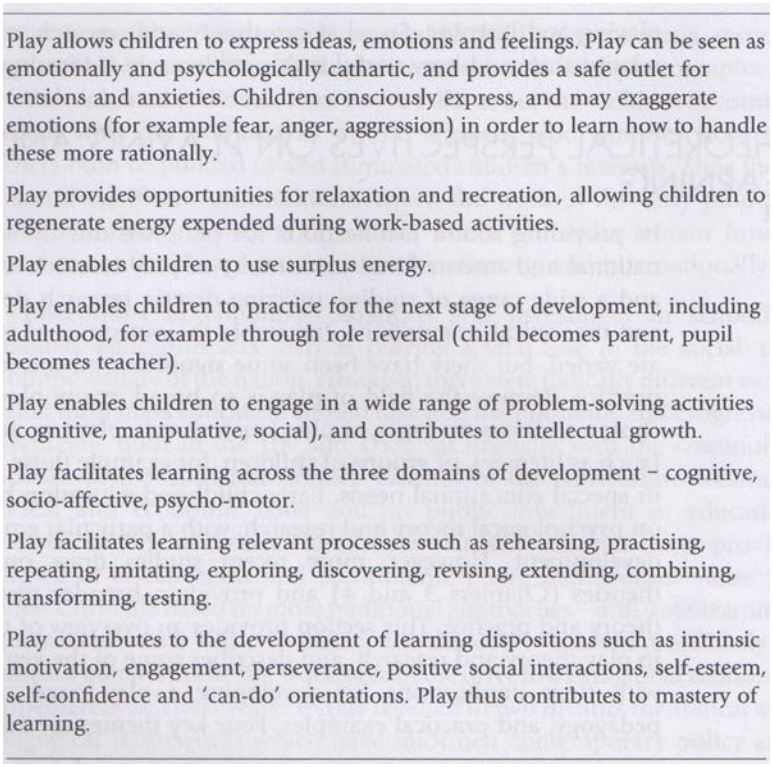


Figure 9: Comparison of Blood Pressure and Muscle Tension of Individuals Placed in Different Environments[92]

[91] Stephen R. Kellert, *Building for Life: Designing and Understanding the Human-Nature Connection* (Washington D.C.: Island Press, 2005), 13.
[92] Stephen R. Kellert, Judith H. Heerwagen, and Martin L. Mador, *Biophilic Design: The Theory, Science, and Practice of Bringing Buildings to Life* (New Jersey: John Wiley & Sons, Inc., 2008), 92.

8.1 PHYSICAL HEALTH

Natural settings encourage outdoor play which is a component vital to physical health. Outoor play, in a residential setting, is tied to the amount of area directly surrounding a house or apartment complex.[93] The benefits of play have been discussed by authors Elizabeth Woods and Jane Attfield (Figure 10). A notable risk for children is sedentary behavior. This type of conduct is increasing among households. There are a few reasons that contribute to an inactive lifestyle and may include: limited access to open or green spaces residential communities; parents that may not encourage physical activity; and computers, gaming consoles, and other electronic devices are occupying a large amount of a child's time.



Play allows children to express ideas, emotions and feelings. Play can be seen as emotionally and psychologically cathartic, and provides a safe outlet for tensions and anxieties. Children consciously express, and may exaggerate emotions (for example fear, anger, aggression) in order to learn how to handle these more rationally.

Play provides opportunities for relaxation and recreation, allowing children to regenerate energy expended during work-based activities.

Play enables children to use surplus energy.

Play enables children to practice for the next stage of development, including adulthood, for example through role reversal (child becomes parent, pupil becomes teacher).

Play enables children to engage in a wide range of problem-solving activities (cognitive, manipulative, social), and contributes to intellectual growth.

Play facilitates learning across the three domains of development – cognitive, socio-affective, psycho-motor.

Play facilitates learning relevant processes such as rehearsing, practising, repeating, imitating, exploring, discovering, revising, extending, combining, transforming, testing.

Play contributes to the development of learning dispositions such as intrinsic motivation, engagement, perseverance, positive social interactions, self-esteem, self-confidence and 'can-do' orientations. Play thus contributes to mastery of learning.

Figure 10: Advantages of Play[94]

[93] Carol S. Weinstein and Thomas G. David, *Spaces for Children: The Built Environment and Childhood Development* (New York: Plenum Press, 1987), 155.
[94] Elizabeth Wood and Jane Attfield, *Play, Learning, and the Early Childhood Curriculum* (Thousand Oaks: SAGE Publications, Inc., 2005), 184-185.

A recent study by sociologist, Stuart J. Olshansky, determined that a growing number of children may die before their parents due to health concerns.[95] In the United States alone, 18 percent of children under 19 years of age are overweight or seriously at risk of being overweight. This disturbing trend is also affecting younger generations. Approximately 10 percent of children between the ages of two and five are obese and more than 20 percent are overweight or at risk of being overweight. The situation in Europe is even grimmer. In Spain, 13.9 percent of individuals between the ages of two and twenty-four are obese and 26.3 percent are overweight.[96]

Nature provides the setting for a myriad of activities that range from hiking, camping, fishing, sports, hunting, and many more. While most of these activities typically occur in *open space*, the term can have a dual meaning. Open space may also refer to areas that allow users to progress from one activity to another freely.[97] People participate in these pastimes for reasons such as physical fitness, recreation, love of nature, scientific interest, and for some, the chance to show off a little. These events not only nurture a healthy relationship with nature but also afford the opportunity to foster social companionship.

A study conducted by outdoor recreational researcher Alan Ewert shows that activity in a park-like environment can lead to significant improvement in physical, physiological, social, and educational aspects. Participation results in increased self-esteem, independence, a better ability to cope with difficult situations, effectiveness, and a likelier chance to take risks. Better coping skills lead to enhanced responsibility, efficiency, organization, and perseverance. Physical gains are made in stamina, strength, endurance, and overall fitness. Social abilities are also developed as far as cooperation, leadership qualities, working in a group setting, learning a non-confrontational behavior, respect for

[95] Robin C. Moore. and Clare C. Marcus, "Healthy Planet, Healthy Children: Designing Nature into the Daily Spaces of Childhood." In *Biophilic Design*, ed. by Stephen R. Kellert et al. (New Jersey: John Wiley & Sons, Inc., 2008), 156.
[96] Robin C. Moore. and Clare C. Marcus, "Healthy Planet, Healthy Children: Designing Nature into the Daily Spaces of Childhood." In *Biophilic Design*, ed. by Stephen R. Kellert et al. (New Jersey: John Wiley & Sons, Inc., 2008), 156.
[97] David E. Day, *Early Childhood Education: A Human Ecological Approach* (Glenview: Scott, Foresman, and Company, 1983), 167

others, and the skills to make new friends.[98] Other, more difficult to measure gains, include peace of mind, deeper spirituality, and clearer philosophical outlooks.

Research conducted by Stephen Kellert, along with Outward Bound, the National Outdoor Leadership School, and the Student Conservation Association, took place over a much longer period of time and indicated the same results. The test group consisted of over eight-hundred participants from all facets of life. The research was conducted over a twenty year period and had subsequent studies performed before, immediately after, and six months after the lengthy phase.[99] The participants reported similar gains as in Ewert's study in so far as improvements to well-being and health.

Physical activity is vital for young children to help with muscle development, motor control, and overall health. Educational psychologist Nilda Cosco studied three preschool environments. One consisted of manufactured play structures, the second combined a mix of natural and built features, and the third had both natural and built features but were segregated from one another. The second preschool proved most beneficial for childhood development. The mix of natural and built environments stimulated more social interaction and led to more active play than the other two sites.[100] These factors also afforded more diversity, duration, and impact of outdoor play.

Taylor Statten, founder of summer activities like Camp Ahmek and Camp Wapomeo in Canada, realized the negative effects of urbanization. He postured:

> "With the trend of our population from the country to the town, it is no longer possible to keep the boys busy during vacation time, raking hay, hoeing corn or even weeding the backyard garden. The dynamic energy with which every active, red-blooded boy is charged must find an outlet. If the energy is not directed and

[98] Stephen R. Kellert, *Building for Life: Designing and Understanding the Human-Nature Connection* (Washington D.C.: Island Press, 2005), 16.
[99] Stephen R. Kellert, *Building for Life: Designing and Understanding the Human-Nature Connection* (Washington D.C.: Island Press, 2005), 17.
[100] Robin C. Moore. and Clare C. Marcus, "Healthy Planet, Healthy Children: Designing Nature into the Daily Spaces of Childhood." In *Biophilic Design*, ed. by Stephen R. Kellert et al. (New Jersey: John Wiley & Sons, Inc., 2008), 163.

> turned to account, it will certainly lead the boy into mischief and quite often into evil ways that will follow him through life. The streets of every city offer no end of dark corners which boys, left to their own devices, will frequent.[101]"

Children desperately need a miniature world, one that emphasizes nature and a departure from consumer culture. While being completely immersed in a natural environment proves most beneficial, any contact with nature in a largely urban environment could promote physical, emotional, and spiritual health. Frequent contact with nature is further enhanced with the removal of household comforts or technological distractions. Youngsters should use raw sensory perception and directly interact with nature rather than view it through a camera lens or from sitting in a chair. The beneficial properties of nature were recognized by Western medical practices and would eventually lead to a new type of hospital architecture.[102] Spas, resorts, and even schools began to follow suit and implement nature into their design or conserve what amenities already existed on site.

Experiential play in outdoor environments boosts a child's immune system. There is a growing concern that readily available chemicals, cleaners, and anti-bacterial products are producing sterile environments. While seemingly an advantage, such clean areas can prevent a youth's immune system from fully developing. Improved hygiene, fewer infections, and a decreased number of parasites has led to the belief that overemphasis of hygiene may have reached a point of diminishing returns.[103] Overly critical hygiene practices may be contributing to the increasing number of asthma and allergic ailments. Exposure to nature, non-sterile environments, may present children with more opportunities to formulate resistances or tolerances to germs and infection.

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[101] Sharon Wall, *The Nurture of Nature: Childhood, Antimodernism, and Ontario Summer Camps, 1920-55* (Vancouver: UBC Press, 2009), 30.
[102] Sharon Wall, *The Nurture of Nature: Childhood, Antimodernism, and Ontario Summer Camps, 1920-55* (Vancouver: UBC Press, 2009), 105.
[103] Robin C. Moore. and Clare C. Marcus, "Healthy Planet, Healthy Children: Designing Nature into the Daily Spaces of Childhood." In *Biophilic Design*, ed. by Stephen R. Kellert et al. (New Jersey: John Wiley & Sons, Inc., 2008), 159.

Exploration in nature leads to the development of useful skills, endurance, self-reliance, cooperation, and helps to form close relationships.[104] Many clubs and associations that promote outdoor activities help children to learn organization skills and discipline since they often follow strict schedules. Such activities are often competitive and in turn, promote teamwork, fair play, and instill the notion of regular and gratifying bouts of leisure in everyday life.[105]

8.2 MENTAL AND EMOTIONAL HEALTH

The natural world boasts many characteristics that can improve cognitive functions and overall mental health. In 2006, psychologist Michael Shayer, in a report sponsored by the Economic and Social Research Council, surveyed over 10,000 11 to 12-year-old British children. The study revealed that children had fallen two to three years behind in cognitive and conceptual development compared to where children of the same age were 15 years ago. When asked for a cause, Shayer postulated:

> "The most likely reasons are the lack of experiential play… and the growth of a video game, TV culture. Both take away the kind of hands-on play that allows kids to experience how the world works in practice and to make informed judgments about abstract concepts.[106]"

Another study conducted by psychologist Nancy M. Wells examined the positive effects that arose from moving low-income children to "greener" homes. The study demonstrated a significant correlation between nature and cognitive functioning.[107]

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[104] Sharon Wall, *The Nurture of Nature: Childhood, Antimodernism, and Ontario Summer Camps, 1920-55* (Vancouver: UBC Press, 2009), 30.
[105] Sharon Wall, *The Nurture of Nature: Childhood, Antimodernism, and Ontario Summer Camps, 1920-55* (Vancouver: UBC Press, 2009), 104.
[106] Robin C. Moore. and Clare C. Marcus, "Healthy Planet, Healthy Children: Designing Nature into the Daily Spaces of Childhood." In *Biophilic Design*, ed. by Stephen R. Kellert et al. (New Jersey: John Wiley & Sons, Inc., 2008), 157.
[107] Robin C. Moore. and Clare C. Marcus, "Healthy Planet, Healthy Children: Designing Nature into the Daily Spaces of Childhood." In *Biophilic Design*, ed. by Stephen R. Kellert et al. (New Jersey: John Wiley & Sons, Inc., 2008), 157.

Exploration of natural environments can potentially stave off mental health disorders. Attention Deficit Disorder (ADD) and Attention Deficit Hyperactive Disorder (ADHD) were not officially designated by the American Psychiatric Association until 1980.[108] ADD/ADHD is generally diagnosed through behavioral criteria and most often characterizes children that lash out from being cooped up indoors. Both disorders are commonly treated with methylphenidate (Ritalin), a psychotropic drug similar in properties to cocaine. An estimated four million children are administered the drug daily, and since 1990 production of Ritalin has increased 700 percent with consumption doubling since 2000.[109] ADD/ADHD could potentially be averted by allowing children to participate in experiential play set in natural environments.

One particular study conducted by Terry Hartig, a social scientist, found that exposure to a park-like setting improves cognitive function. Three control groups of college students were placed in different environments. For a forty-minute period two groups went on a walk, one through a park and the other through an urban area, while the third group remained indoors in a comfortable setting. After the lapse of the predetermined period the students were given a proofreading assignment. The students who strolled through the park demonstrated greater attentiveness and concentration whereas the other groups displayed much less intellectual gain.[110] While rest and relaxation are a major benefit, open spaces also provide a chance for physical stimulation.

If physical contact with the natural environment is not possible even providing views of scenery or landscaped areas can greatly improve the average demeanor. Views of plant-filled surroundings have long been believed to provide calm, soothing feelings. If views of nature are not available, even representations such as paintings, pictures, or posters can considerably improve an individual's temperament. While a long held truth, there are

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[108] Robin C. Moore. and Clare C. Marcus, "Healthy Planet, Healthy Children: Designing Nature into the Daily Spaces of Childhood." In *Biophilic Design*, ed. by Stephen R. Kellert et al. (New Jersey: John Wiley & Sons, Inc., 2008), 157.
[109] Robin C. Moore. and Clare C. Marcus, "Healthy Planet, Healthy Children: Designing Nature into the Daily Spaces of Childhood." In *Biophilic Design*, ed. by Stephen R. Kellert et al. (New Jersey: John Wiley & Sons, Inc., 2008), 158.
[110] Stephen R. Kellert, *Building for Life: Designing and Understanding the Human-Nature Connection* (Washington D.C.: Island Press, 2005), 15.

now scientific studies to back the therapeutic properties of viewing green spaces and gardens.

Analgesic Strength	Number of Pain Drug Doses (days 2-5 after surgery)	
	Nature View Patients	**Wall** View Patients
Strong	0.96	2.48
Moderate	1.74	3.65
Weak	5.39	2.57

Table 6: Doses of Varying Analgesic Strength Requested by Post-Surgery Patients[111]

Roger Ulrich, an environmental geographer and psychologist, observed hospital patients recovering from surgery. The people involved were placed in one of two rooms: one held a view of trees and vegetation while the other looked directly at a brick wall. The patients placed in rooms that viewed natural scenery had much fewer post-surgery complications, held a much more positive outlook, required less medication, and indeed, recovered faster.[112] Those with views of nature often requested weak analgesic medication compared to patients who opted for strong analgesic responses post-surgery (Table 6).

Ulrich completed another study based on recovery patients that may not have any views available to them. In these instances, three controls were established: rooms with pictures of natural water features and nature scenes, quarters with abstract art, and accommodations with nothing but blank walls. Patients placed in rooms with pictures of nature reported much less complaints and requests for pain medication. They were also reported to have less anxiety and stress. Conversely, the patients with the abstract art were described as having the highest stress, post-surgery problems, and launched the

[111] Stephen R. Kellert, Judith H. Heerwagen, and Martin L. Mador, *Biophilic Design: The Theory, Science, and Practice of Bringing Buildings to Life* (New Jersey: John Wiley & Sons, Inc., 2008), 95.
[112] Stephen R. Kellert, *Building for Life: Designing and Understanding the Human-Nature Connection* (Washington D.C.: Island Press, 2005), 21.

most complaints.[113] The same pictorial representations were used at a psychiatric institution. The patients viewing the nature scenes were more docile and benevolent, whereas those who looked at abstract art were more agitated and belligerent, and in some cases, often nonaggressive individuals even destroyed the art mosaics.[114] Actual interaction with nature serves as the best restorative option, but where not applicable, at least views or representations should suffice to improve human well-being.

Ulrich's studies focused primarily on the restorative capacity of exposure to nature, but it can also be preventative. The average study environment, by modern standards, is a climate-controlled indoor setting. Large buildings, like libraries, are subdivided into workstations or smaller spaces with only those at the outermost reaches able to receive natural light. These contemporary areas are often characterized by predominantly artificial lighting, minimal to no natural ventilation, and cramped quarters. Unfavorable conditions like those aforementioned can lead to "sick building syndrome" and "building-related illness."[115] Such ailments typically entail respiratory problems, skin disorders, fatigue, and can sometimes lead to psychological duress. This can lead to individuals reporting higher amounts of absences, poor productivity, and low morale.

The addition of potted plants, views of nature, natural ventilation and light have resulted in a much more favorable environment. Simply being able to see nature from a site has resulted in lower stress and substantially greater emotional well-being. Just having windows for natural light can promote better physical and mental health and result in less frustration. Studies of office work spaces have determined that those with the least work-related debilitations were located close to windows. Those with higher reports of discomfort were situated away from windows near the middle of the office or near the core (Figure 11).

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[113] Stephen R. Kellert, *Building for Life: Designing and Understanding the Human-Nature Connection* (Washington D.C.: Island Press, 2005), 22.
[114] Stephen R. Kellert, *Building for Life: Designing and Understanding the Human-Nature Connection* (Washington D.C.: Island Press, 2005), 22.
[115] Stephen R. Kellert, *Building for Life: Designing and Understanding the Human-Nature Connection* (Washington D.C.: Island Press, 2005), 23.

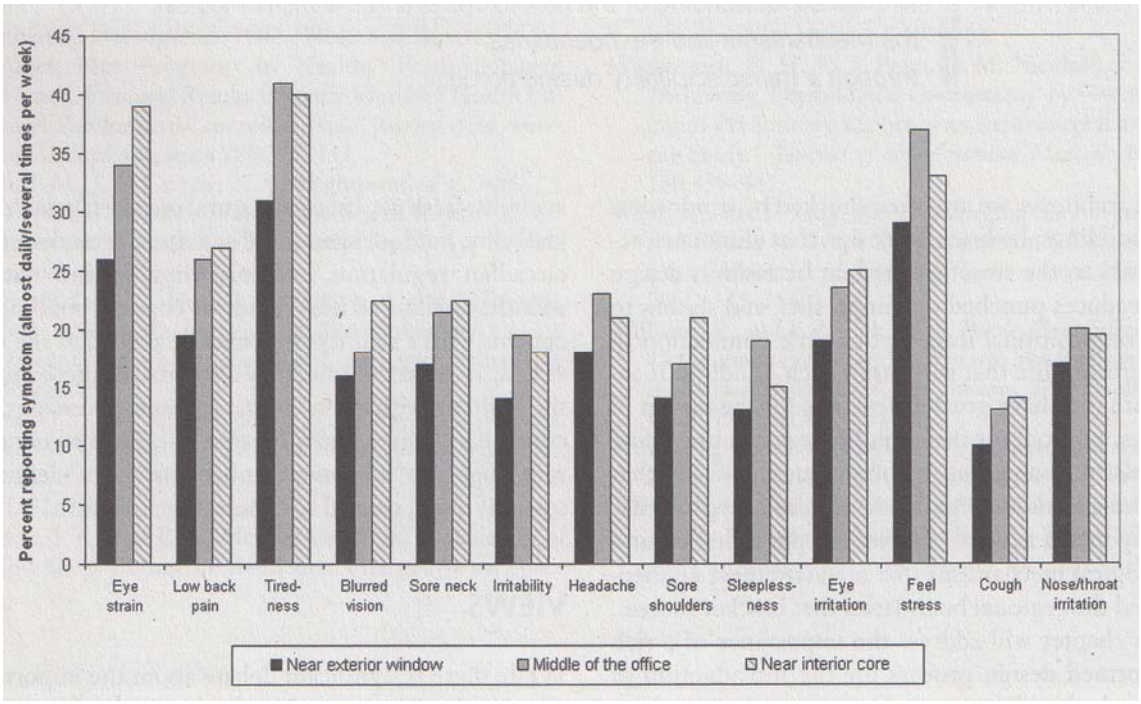

Figure 11: Work-Related Discomfort Reported by Employees Based on Location in Office[116]

Areas devoid of any window spaces are more likely to be decorated by individuals with photos or pictures of nature and even the occasional potted plant or two. Potted plants at desk can lead to smaller amounts of allergens in the environment, and encourages better attentiveness and lower blood pressure (Figure 12). Natural ventilation and lighting further add to the positive effects within a work area. Several companies were studied to measure gains in productivity and health that resulted from having access to natural environments (Figure 13). The presence of at least one of these conditions greatly enhances performance, minimizes errors, creates greater awareness, eases stress, reduces fatigue, and reduces the potential of contracting an illness.[117] These same principles apply to study areas of a much smaller scale and have the same conceptual impact in a residential work area.

[116] Stephen R. Kellert, Judith H. Heerwagen, and Martin L. Mador, *Biophilic Design: The Theory, Science, and Practice of Bringing Buildings to Life* (New Jersey: John Wiley & Sons, Inc., 2008), 120.
[117] Stephen R. Kellert, *Building for Life: Designing and Understanding the Human-Nature Connection* (Washington D.C.: Island Press, 2005), 25.

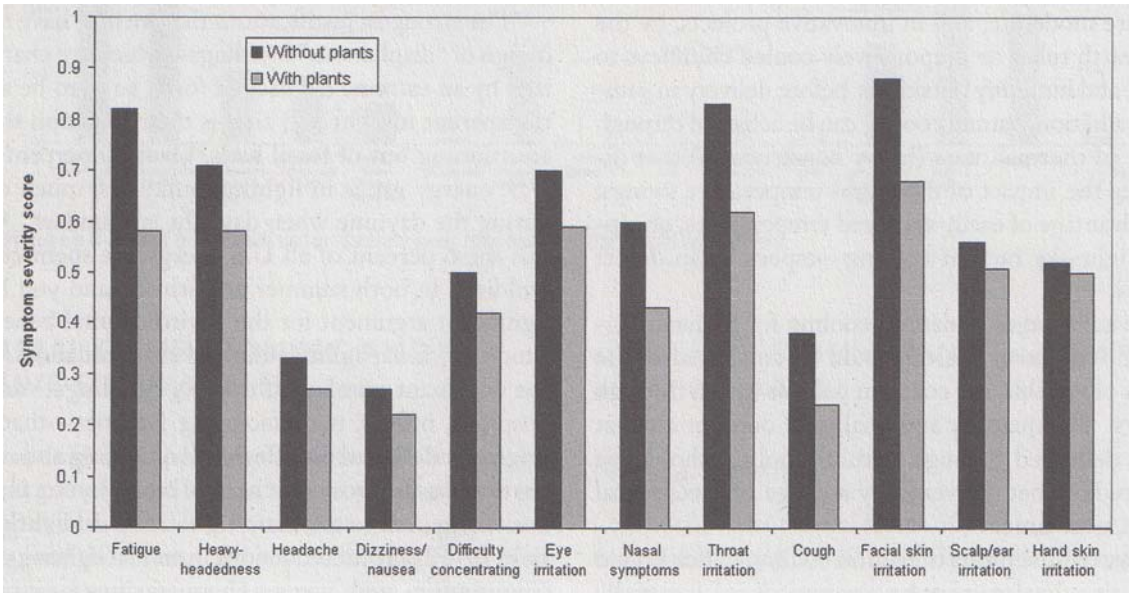

Figure 12: Affects of Potted Plants on Common Office Discomforts[118]

Natural and landscaped environments have proved their worth in the outdoors and in a work setting, but they also have value in residential areas. Newer housing developments don't usually have the luxury of large open space and often result in densely populated accommodations. In these areas, it is a good idea to at least have some sort of communal park space for activity and congregation. Residences with large yards or public park spaces are afforded much the same benefits as in the outdoors or at work with incorporated scenery with a couple added perks. Public parks and walkways promote neighborly relations and a much cheerier persona. Residents in housing areas with such planned throughways and parks demonstrate better interpersonal relationships with neighbors and even strangers.[119] Subsequently, these neighborhoods also experience a greater feeling of security and social responsibility for the well-being of others.

[118] Stephen R. Kellert, Judith H. Heerwagen, and Martin L. Mador, *Biophilic Design: The Theory, Science, and Practice of Bringing Buildings to Life* (New Jersey: John Wiley & Sons, Inc., 2008), 128.
[119] Stephen R. Kellert, *Building for Life: Designing and Understanding the Human-Nature Connection* (Washington D.C.: Island Press, 2005), 30.

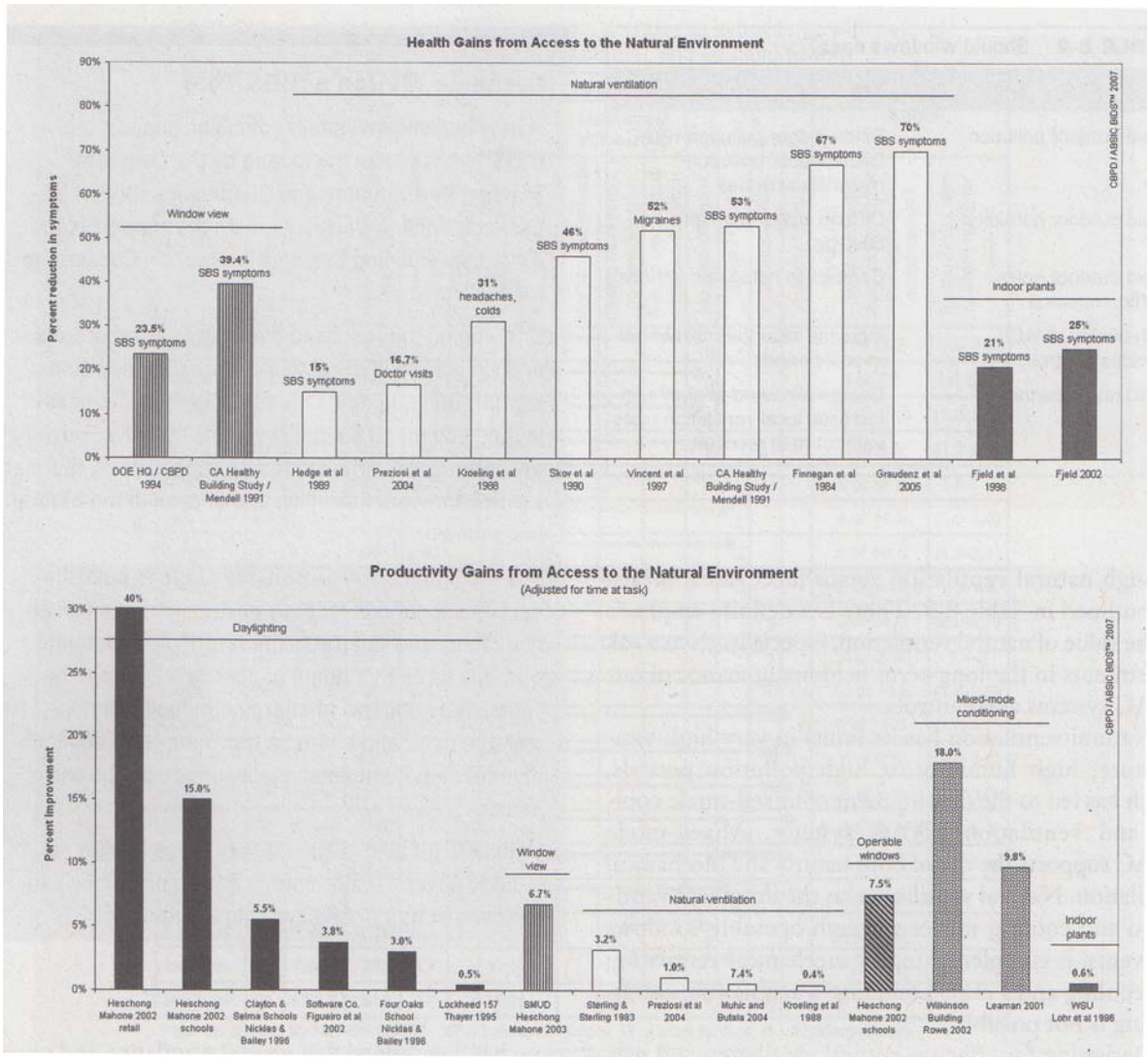

Figure 13: Health and Productivity Gains in Various Companies with Access to Natural Environments[120]

Experiences in nature can help to strengthen religious beliefs. Magnificent scenery and blissful environments often invite contemplation and lead to a closer communion with God or higher powers. Such awe-inspiring scenery often required no explanation to be connected to a religious message. Nature coupled with religion often removed all negative tendencies and left participants highly impressionable to positive life lessons.

[120] Stephen R. Kellert, Judith H. Heerwagen, and Martin L. Mador, *Biophilic Design: The Theory, Science, and Practice of Bringing Buildings to Life* (New Jersey: John Wiley & Sons, Inc., 2008), 126.

8.3 SOCIAL HEALTH

Children who participate in experiential play in natural settings harbor positive impacts to social capacities. Natural surroundings offer more opportunities for cooperative group play. Young kids learn to organize informal games, build a clubhouse, or go exploring with no particular goals set forth (Figure 14). The friendships and collaborative relationships that evolve help to develop democratic skills, facilitate cooperation and collective efforts, and can even help overcome prejudices about children from different backgrounds.[121] Children with trustworthy friends are more likely to be outgoing, have improved self-esteem, and work well in group-oriented activities.

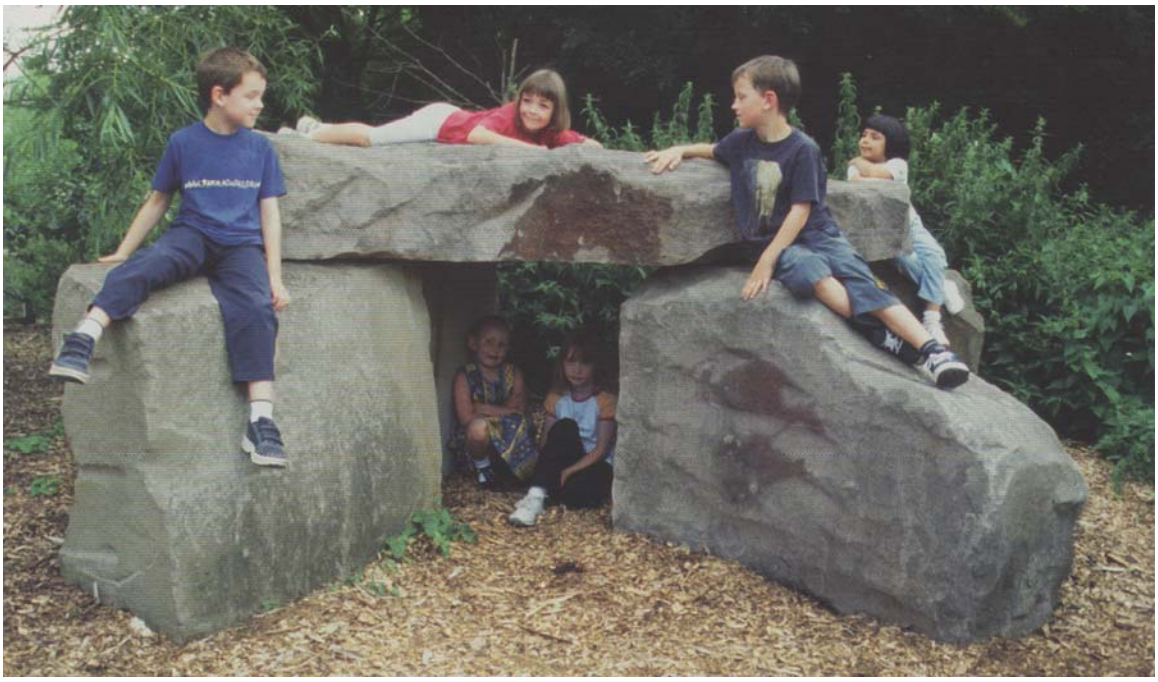

Figure 14: Children Improve Social Skills at a Stone Clubhouse[122]

Swedish researcher Patrik Grahn conducted a study on the impacts of natural environments in two Swedish nursery schools. Both facilities were equipped with

[121] Robin C. Moore. and Clare C. Marcus, "Healthy Planet, Healthy Children: Designing Nature into the Daily Spaces of Childhood." In *Biophilic Design*, ed. by Stephen R. Kellert et al. (New Jersey: John Wiley & Sons, Inc., 2008), 158.
[122] Stephen R. Kellert, Judith H. Heerwagen, and Martin L. Mador, *Biophilic Design: The Theory, Science, and Practice of Bringing Buildings to Life* (New Jersey: John Wiley & Sons, Inc., 2008), 251.

conventional playground equipment, but one was allowed access to a woodland area for children to explore. Those allowed access to the forested area displayed improved attention functioning, lower sickness rates, advanced gross motor development, improved fitness, increased imagination, and improved social play.[123] Planted areas and park spaces are invaluable to urban environments where children may not have easy access to naturally vegetated amenities. These areas allow children to escape from the restrictions of home, meet up with peers, have fun, enjoy nature, and learn about themselves and the natural world around them (Figure 15).

Figure 15: Children Engage in Explorative and Cooperative Play in the Natural World[124]

[123] Robin C. Moore. and Clare C. Marcus, "Healthy Planet, Healthy Children: Designing Nature into the Daily Spaces of Childhood." In *Biophilic Design*, ed. by Stephen R. Kellert et al. (New Jersey: John Wiley & Sons, Inc., 2008), 158.
[124] Stephen R. Kellert, Judith H. Heerwagen, and Martin L. Mador, *Biophilic Design: The Theory, Science, and Practice of Bringing Buildings to Life* (New Jersey: John Wiley & Sons, Inc., 2008), 251.

8.4 PSYCHOLOGICAL IMPLICATIONS

The positive effects of interaction with nature garnered much attention from psychological disciplines. Many felt that natural environments were necessary for well-being.[125] During the late 19th century, children were viewed as dependent and in need of protection. This view led to the creation of compulsory schooling and separate educational institutions. The 20th century view changed little and was further galvanized by scientific and professional expertise. Psychology was branching into new areas, and in particular, examined child development as a distinct stage of human experience.

Psychologists aimed to improve society in the future by altering psychological conditions of childhood within different environments such as in the home, at school, or in the community at large. The *permissive model* was implemented to his effect. [126] The plan realized personality development occurred mainly during childhood and the necessity for schools to closely monitor progress. Observation included physical growth, mental health, and investigation of child interaction with natural environments.

In North America, psychological studies were closely tied to what was referred to as mental hygiene. The movement, which started in 1910 and developed through 1960, viewed mental deficiencies as being largely hereditary. Undesirable traits such as laziness, immorality, and even criminal tendencies were thought to be inherited.[127] Psychologists who believed in mental hygiene were relegated to identifying individuals with any deficiencies in hopes of rectifying unfavorable character traits early on.

Mental hygiene extensively examined childhood development since it was believed that early experiences proved most influential to an individual. In this way, mental illnesses or disorders stemming from early events could be treated. The preventative stipulations of mental hygiene had great appeal to the public at large and often incorporated into

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[125] Sharon Wall, *The Nurture of Nature: Childhood, Antimodernism, and Ontario Summer Camps, 1920-55* (Vancouver: UBC Press, 2009), 140.
[126] Sharon Wall, *The Nurture of Nature: Childhood, Antimodernism, and Ontario Summer Camps, 1920-55* (Vancouver: UBC Press, 2009), 144.
[127] Sharon Wall, *The Nurture of Nature: Childhood, Antimodernism, and Ontario Summer Camps, 1920-55* (Vancouver: UBC Press, 2009), 142.

child-rearing education or developmental literature. Committees for promoting mental hygiene were established in the United States and Canada in 1908 and 1918, respectively.[128] Psychological studies slowly shifted from confined laboratories to open, public spaces.

While the mental hygiene movement was being developed, another school of psychologists postured that human traits were not entirely hereditary, but a result of a environmental influences. This theory opened up a broad range of study since characteristic flaws were deemed treatable through engaging various surroundings. Since early experiences were seen as substantial to personality development, psychologists focused much of their investigation on the formative childhood years. Children were understood to move through distinct stages during maturation towards adulthood, a notion that can be traced back to Darwinian theories of evolution, but had resurfaced in 20th century psychology.

Entrepreneurs like American behavioral psychologists John B. Watson, and later B.F. Skinner, championed the impressionable personality theory. They viewed infancy as the equivalent to a blank canvas. Babies had certain survival instincts like hunger, thirst, a need for warmth, but beyond that, personality traits were the result of external forces. Child psychologists began to turn away from simply observing infant behavior, but to try and shape it towards a favorable outcome. Habit training which promoted intensive scheduling became common practice and served as the foundation for many early instructional programs and parental literature.[129]

Contrast to Watson and Skinner, many Freudian psychologists attributed personality development to a child's inner desires. These innate ambitions were believed to be the motivation behind behavior. The Freudian theory fell in between the mental hygiene movement with heredity as a basis, and the school of thought that attributes character

[128] Sharon Wall, *The Nurture of Nature: Childhood, Antimodernism, and Ontario Summer Camps, 1920-55* (Vancouver: UBC Press, 2009), 143.
[129] Sharon Wall, *The Nurture of Nature: Childhood, Antimodernism, and Ontario Summer Camps, 1920-55* (Vancouver: UBC Press, 2009), 144.

formulation with environmental influences. Children were deemed to have intrinsic values that superseded behavioral conditioning[130]. From this point of view, the child was viewed as an individual with unique emotional needs rather than an impressionable personality to be subjected to behavioral control.

The Canadian child psychologist, William E. Blatz, fashioned a progressive view of child psychology that was based on environmentalist and the Freudian concepts. His theory incorporated behavioral training, strict scheduling, and detailed note-taking. At the same time, Blatz refuted the use of coercion to modify a child's mannerisms and limited interference with natural intuitions. This type of "free-choice learning" provided stiff contrast to the conformity of habit-training. He was concerned with the emotional world of a child and their constant search for a feeling of security. Blatz's ideals were coveted for utilizing "the natural history model." Practitioners of this model contested the efficiency of laboratory research since it was artificial and not likely to produce natural responses from children.[131] While scientific research calls for controlled variables and environments, it limits the possible outcomes and often prevents leads to predictable results.

[130] Sharon Wall, *The Nurture of Nature: Childhood, Antimodernism, and Ontario Summer Camps, 1920-55* (Vancouver: UBC Press, 2009), 144.
[131] Sharon Wall, *The Nurture of Nature: Childhood, Antimodernism, and Ontario Summer Camps, 1920-55* (Vancouver: UBC Press, 2009), 144.

9.0 BIOPHILIC DESIGN

Since our earliest existence, mankind has coexisted with nature and relied on the environment to provide habitable areas. Natural geography, such as caves and outcroppings, served as the first dwellings. As human ingenuity increased, crude shelters were constructed to provide livable spaces regardless of the surrounding conditions. Upon the advent of technology and engineered materials, mankind's dominance over nature further improved. Indeed it is often a sign of modernity for the built environment to supersede naturally existing conditions. Hills and knolls are leveled for roads, slopes are terraced for development, and forests are cleared in favor of open space. Yet, even after mankind demonstrated a commanding presence by creating large cities, great effort went in to maintaining some form of contact with nature. Gardens for ancient Egyptians, walled gardens for Persian establishments in Mesopotamia, and the gardens of merchants in medieval Chinese cities all indicate considerable effort to incorporate nature.[132]

Biophilia holds that nature, and other living beings, area a source of emotional health. The destruction of nature, or exclusion in design, is essentially depriving human beings of countless opportunities for emotional fulfillment.[133] While such alteration of the natural world has led to the formation of large urban areas, there is a design approach that attempts to link nature and human well-being. The design aesthetic that focuses on this relationship is the concept of *biophilia*. The term refers the mankind's inherent affinity for natural phenomena.[134] When coupled with the need to answer the current energy crisis and overconsumption of natural resources, a new design stratagem was formulated.

Deemed *restorative environmental design*, the method attempts to reduce excessive energy and material expenditure while reconnecting humans to the natural world. Restorative environmental design recognizes the increased detachment from natural

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[132] Stephen R. Keller and Edward O. Wilson, *The Biophilia Hypothesis* (Washington D.C.: Island Press, 1993), 73.
[133] Kay Milton, *Loving Nature: Towards an Ecology of Emotion* (London: Routledge, 2002), 61
[134] Stephen R. Kellert, *Building for Life: Designing and Understanding the Human-Nature Connection* (Washington D.C.: Island Press, 2005), 3.

environments. It also highlights current design trends which result in unsustainable energy consumption, wasteful material practices, massive biodiversity loss, widespread chemical pollution, atmospheric degradation, and climate change.[135] The concern for habitat degradation, loss of biodiversity, and preservation of the natural setting is referred to as *low environmental impact design*.[136] This technique encompasses energy and resource efficiency, sustainable products and materials, safe waste generation and disposal methods, pollution reduction, and indoor environmental quality.[137] These types of concerns have translated into guidelines and incorporated in the U.S. Green Building Council's LEED (Leadership in Energy and Environmental Design) approach.

Mankind's relationship with the natural environment can be experienced on many different levels and is often dependant on an individual's interpretation of "nature." The most basic view would consider nature to be interaction with domesticated animals, landscaped areas, or even potted plants. On the other end of the spectrum, nature describes the wilderness, natural vegetation, and areas unaffected or unaltered by human influence. Experiencing nature is not limited to direct physical contact as there are many other avenues. Books, television programs, and photos offer invaluable educational material. Regardless of how knowledge of nature is obtained it is vitally important for human development. Incorporating nature into the average lifestyle has been linked to improved functionality, quicker recovery from illness, reduced stress, and a higher quality of life.[138] The presence of nature has also been linked to fewer social problems, healthy childhood maturation and development, and enhanced brain functionality when drawing from cues found in the natural environment.[139] Considering the presence of

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[135] Stephen R. Kellert, Judith H. Heerwagen, and Martin L. Mador, *Biophilic Design: The Theory, Science, and Practice of Bringing Buildings to Life* (New Jersey: John Wiley & Sons, Inc., 2008), 5.
[136] Stephen R. Kellert, *Building for Life: Designing and Understanding the Human-Nature Connection* (Washington D.C.: Island Press, 2005), 4-5.
[137] Stephen R. Kellert, Judith H. Heerwagen, and Martin L. Mador, *Biophilic Design: The Theory, Science, and Practice of Bringing Buildings to Life* (New Jersey: John Wiley & Sons, Inc., 2008), 5.
[138] Stephen R. Kellert, *Building for Life: Designing and Understanding the Human-Nature Connection* (Washington D.C.: Island Press, 2005), 12.
[139] Stephen R. Kellert, Judith H. Heerwagen, and Martin L. Mador, *Biophilic Design: The Theory, Science, and Practice of Bringing Buildings to Life* (New Jersey: John Wiley & Sons, Inc., 2008), 4.

nature can improve human well-being in the home, at work, and through recreation, inclusion into everyday life is extremely valuable.

Biophilic design is an important part in modern society where contemporary glass and steel structures tend to dominate the building industry. While many of them are taking strides towards sustainability, they will not make nearly as much gain as a design that also incorporates biophilic principles. The design industry is being reshaped by the "green" movement. Sustainable practices are being put in place to ensure we do not consume resources faster than they can be replenished. Recognition of the world's energy woes is commendable, but extra effort should be taken to reconnect with the natural environment. This added objective is the basis for *biophilic design*. It is a holistic approach that can be incorporated in the facade, interior, landscaping, or even as decorative elements in buildings.

9.1 TWO DIMENSIONS OF BIOPHILIC DESIGN

Biophilic design can be identified by two dimensions, followed by six elements, which are then related to seventy-two biophilic design attributes.[140] The two dimensions are *organic* or *naturalistic* and *vernacular* or *place-based* design. The organic dimension emulates natural forms based on direct, indirect, or symbolic affinities between man and nature. Direct experiences describe contact with unaltered, natural elements such as daylight, plants, animals, natural habitats and ecosystems. Indirect experience entails contact with natural elements which require ongoing human interaction to survive. These items can include potted plants, a water fountain, or an aquarium. Symbolic experience does not have any direct contact with nature and portrays interaction with representations such as posters, pictures, videos or magazines.[141] The built environment largely offers indirect experiences and often symbolic representations. Though direct experiences occasionally occur, they are much more limited than the other two types. The term

[140] Stephen R. Kellert, Judith H. Heerwagen, and Martin L. Mador, *Biophilic Design: The Theory, Science, and Practice of Bringing Buildings to Life* (New Jersey: John Wiley & Sons, Inc., 2008), 5.
[141] Stephen R. Kellert, Judith H. Heerwagen, and Martin L. Mador, *Biophilic Design: The Theory, Science, and Practice of Bringing Buildings to Life* (New Jersey: John Wiley & Sons, Inc., 2008), 5-6.

"organic design" was originally coined by the famous architect Frank Lloyd Wright.[142] The term has come to encompass natural lighting, natural materials, and incorporating views of the surrounding landscape into design.

Wright's definition of organic design was further expanded on by architect Grant Hildebrand. He portrayed organic design as having high ceilings, extensive natural light, elevated living spaces to provide dramatic views, play of light through colored glass, terraces to offer multiple vantage points into the distance, winding paths that lead to concealed entries, incorporation of the building into the site through long horizontal planes, and visual connections between interior rooms with expansive views to the outside.[143] Writer David Pearson also added his own comments to the definition of organic design. He felt it should be inspired by nature, represent and organism, exist in the "continuous present," follow natural flows, be flexible, and appear to grow out of the site.[144]

The vernacular dimension caters to a particular environment and the local culture of the area. Without this connection a design would not hold the same significance and could be recreated anywhere in the world with relatively the same amount of importance. Four ways to ensure a successful vernacular design is to keep in mind the local ecology, the cultural and social traditions of the area, fuse ecology and culture for a tie into historical context, and avoid losing local identity and spirit of place.[145] If a healthy respect for these conditions can be maintained, a prominent design will be established. In modern society it is easy to lose sight of the potential worth of a structure. Edward Relph mentioned in his book:

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[142] Stephen R. Kellert, *Building for Life: Designing and Understanding the Human-Nature Connection* (Washington D.C.: Island Press, 2005), 130.
[143] Stephen R. Kellert, *Building for Life: Designing and Understanding the Human-Nature Connection* (Washington D.C.: Island Press, 2005), 131.
[144] Stephen R. Kellert, *Building for Life: Designing and Understanding the Human-Nature Connection* (Washington D.C.: Island Press, 2005), 133.
[145] Stephen R. Kellert, *Building for Life: Designing and Understanding the Human-Nature Connection* (Washington D.C.: Island Press, 2005), 167.

> "If places are indeed a fundamental aspect of existence in the world, if they are sources of security and identity for individuals and for groups of people, then it is important that the means of experiencing, creating, and maintaining significant places are not lost. There are signs that these very means are disappearing and that "placelessness" – the weakening of distinct and diverse experiences and identities of places – is now a dominant force. Such a trend marks a major shift in the geographical bases of existence from a deep association with places to rootlessness."[146]

People are more motivated to care for buildings and structures that have a strong social or cultural tie to the local traditions. There is a natural human longing for a place to call "home" and a natural inclination to be territorial. A sense of home is usually characterized by a sense of security, a means of obtaining resources, and a way to avoid danger.

9.2 SIX ELEMENTS OF BIOPHILIC DESIGN

The two dimensions of biophilic design can be further subdivided into six elements. They include environmental features, natural shapes and forms, natural patterns and processes, light and space, place-based relationships, and evolved human-nature relationships. Each element has a subset of characteristics to further explain traits of biophilic design. These seventy-two attributes govern favorable characteristics that can improve human comfort, demeanor, and provide visual interest. An overview of the six elements and seventy-two attributes is provided in Table 7.

[146] Edward C. Relph, *Place and Placelessness* (London: Pion, 1976), 12.

TABLE 1-1 Elements and Attributes of Biophilic Design

Environmental features	Natural shapes and forms	Natural patterns and processes
Color	Botanical motifs	Sensory variability
Water	Tree and columnar supports	Information richness
Air	Animal (mainly vertebrate) motifs	Age, change, and the patina of time
Sunlight	Shells and spirals	Growth and efflorescence
Plants	Egg, oval, and tubular forms	Central focal point
Animals	Arches, vaults, domes	Patterned wholes
Natural materials	Shapes resisting straight lines and right angles	Bounded spaces
Views and vistas		Transitional spaces
Façade greening	Simulation of natural features	Linked series and chains
Geology and landscape	Biomorphy	Integration of parts to wholes
Habitats and ecosystems	Geomorphology	Complementary contrasts
Fire	Biomimicry	Dynamic balance and tension
		Fractals
		Hierarchically organized ratios and scales
Light and space	**Place-based relationships**	**Evolved human-nature relationships**
Natural light	Geographic connection to place	Prospect and refuge
Filtered and diffused light	Historic connection to place	Order and complexity
Light and shadow	Ecological connection to place	Curiosity and enticement
Reflected light	Cultural connection to place	Change and metamorphosis
Light pools	Indigenous materials	Security and protection
Warm light	Landscape orientation	Mastery and control
Light as shape and form	Landscape features that define building form	Affection and attachment
Spaciousness		Attraction and beauty
Spatial variability	Landscape ecology	Exploration and discovery
Space as shape and form	Integration of culture and ecology	Information and cognition
Spatial harmony	Spirit of place	Fear and awe
Inside-outside spaces	Avoiding placelessness	Reverence and spirituality

Table 7: Six Biophilic Elements and Their Corresponding Attributes[147]

[147] Stephen R. Kellert, Judith H. Heerwagen, and Martin L. Mador, *Biophilic Design: The Theory, Science, and Practice of Bringing Buildings to Life* (New Jersey: John Wiley & Sons, Inc., 2008), 15.

ENVIRONMENTAL FEATURES

Environmental features involve the use of natural features in the built environment. There are twelve attributes associated with environmental features and include:

- Color
- Water
- Air
- Sunlight
- Plants
- Animals
- Natural materials
- Views and vistas
- Façade greening
- Geology and landscape
- Habitats and ecosystems
- Fire

Color has played an essential role in human survival from the earliest of days. Color has helped to locate food, resources, water, indicate danger, and served as a means of identification.[148] Color has even been used to aid in wayfinding.[149] There is an affinity to natural colors, like earth tones, since the earliest available materials were often restricted to stone, lumber, grass, reeds, and other naturally occurring items. However, human beings are equally captivated by flowers, rainbows, and sunsets that have a multitude of bright colors. Vertical walls provide an opportunity to display various colors. Plants selected may have leaves, flowers, or buds to create colorful contrasts to the predominantly green backdrop.

[148] Stephen R. Kellert, Judith H. Heerwagen, and Martin L. Mador, *Biophilic Design: The Theory, Science, and Practice of Bringing Buildings to Life* (New Jersey: John Wiley & Sons, Inc., 2008), 7.
[149] Dak Kopec, *Environmental Psychology for Design* (China: Fairchild Publications, 2006), 94.

Water is the basis for all life, and as such, evokes a strong response from viewers. As stated by John Ruskin:

> "As far as I can recollect, without a single exception, every Homeric landscape, intended to be beautiful is composed of a fountain, a meadow, and a shady grove."[150]

Figure 16: Pavilion and Reflecting Pool, Toronto, Ontario, Canada

Water can present soothing undertones and create a calm and relaxed setting (Figure 16). Utilization of water as a design feature takes careful consideration. When implementing water as a design element, attention must be paid to perceptions of quality, quantity, movement, clarity, and other characteristics.[151] The sound of splashing water can be a calm and soothing element, but if overdone, it can be loud, raucous, and a distraction. Water features could potentially be a safety hazard if floor surfaces become slick and slippery. Vertical gardens employ water as a means to nurture plants, but could also have

[150] Grant Hildebrand, *Origins of Architectural Pleasure* (Berkeley: University of California Press, 1999), 71.
[151] Stephen R. Kellert, Judith H. Heerwagen, and Martin L. Mador, *Biophilic Design: The Theory, Science, and Practice of Bringing Buildings to Life* (New Jersey: John Wiley & Sons, Inc., 2008), 7.

other functional and educational ramifications. Plants, and growing medium, have the potential to act as a first-line filter in water reclamation or reuse capacities. This process has tremendous educational value to children since it involves natural processes and the conservation or reuse of resources.

Air is intrinsically preferred to come from natural ventilation, but the modern reality is that most buildings will utilize processed, recirculated air. Natural ventilation can also pose a problem if gusts into the building have the potential to shift objects about. Design considerations include quality, movement, flow, stimulation of other senses such as feel and smell, and visual appeal despite the seeming invisibility of the atmosphere.[152] Vegetation selected for vertical gardens act as filters and can remove dust, pollen, and other pollutants from the air. While not exactly a visible process, children will nonetheless benefit from being aware of a vertical garden's air purifying capabilities.

Sunlight, most often referred to as daylight, is a very commonly preferred building feature (Figure 17). An individual's fundamental needs for daylighting include: a 24-hour cycle of illumination that includes periods of darkness and of bright light, exposure to bright daylight during winter months, the need to feel a sense of contact with the outside world, and avoidance of glare that may cause discomfort.[153] Insufficient exposure to natural light can lead to seasonal affective disorder (SAD) or vitamin D deficiencies.[154] The use of natural light as opposed to artificial light can improve morale, comfort, health, and productivity. Human dependency on natural light defines our species as diurnal creatures and emphasizes the need for light for securing resources, completing tasks, and avoiding danger. By their very nature, vertical gardens encourage outdoor activity and coax people out of buildings. Careful consideration must be taken to ensure plants will receive adequate sunlight. Indoor vertical gardens can prompt discussions of natural light penetrating a building. Not only will it provide much needed

[152] Stephen R. Kellert, Judith H. Heerwagen, and Martin L. Mador, *Biophilic Design: The Theory, Science, and Practice of Bringing Buildings to Life* (New Jersey: John Wiley & Sons, Inc., 2008), 7.
[153] Peter Tregenza and Michael Wilson, *Daylighting: Architecture and Lighting Design* (New York: Routledge, 2011), 5-6.
[154] Stephen R. Kellert, Judith H. Heerwagen, and Martin L. Mador, *Biophilic Design: The Theory, Science, and Practice of Bringing Buildings to Life* (New Jersey: John Wiley & Sons, Inc., 2008), 7.

energy to the plants, but it will also provide an added modicum of comfort for building users.

Figure 17: Abundance of Daylighting, National Portrait Gallery, Washington D.C.[155]

Plants are vital since they serve as sources of food, material, fodder, and can even provide a sense of security. The presence of plants within the built environment can lead to greater comfort, satisfaction, well-being, and performance.[156] Plants are not only functional sources of goods, but they also provide an invaluable aesthetic aspect. Vegetation can create much needed contrast in a built environment and can lead to reduced stress, less fatigue, and greater attentiveness.

Animals, just as plants, have traditionally been viewed as a commodity and source of food, resources, protection, and companionship. Animals, as they pertain to the built environment can evoke feelings of satisfaction, pleasure, stimulation, emotional interest,

[155] http://arugulafiles.typepad.com/.a/6a00e55091ba2f883300e5543fdcca8834-500wi
[156] Stephen R. Kellert, Judith H. Heerwagen, and Martin L. Mador, *Biophilic Design: The Theory, Science, and Practice of Bringing Buildings to Life* (New Jersey: John Wiley & Sons, Inc., 2008), 7.

and entertainment.[157] Implementing animals into design can be a difficult task unless used for aviaries, zoos, or aquariums. Some cases, such as green roofs, may have specific species introduced to maintain the delicate balance of the planned ecosystem. In most instances, animals will appear in a symbolic fashion as posters, photos, or painted images. Vertical gardens can indirectly incorporate animals. Large collections of vegetation will eventually host a range of bird-life, insects, and small reptiles. Even at such a small scale children can learn about processes like life and death, reproduction, evolution, and cohabitation.

Natural materials are favored over artificial replications. Natural materials, unlike their artificial counterparts, tend to display wear, aging, or weathering and evoke a stronger response with the passage of time. Natural materials also have a tendency to elicit a higher sense of responsibility for care and maintenance. Plants employed by vertical gardens serve as natural materials in the truest sense and are affected by age, weather, and disease. Their well-being requires dutiful upkeep, time, and emotional investment.

Views and vistas are desired for viewing purposes, especially those that accentuate natural features or implement vegetation. The most important aspect of views and vistas is the consideration of scale. Any vantage point should not be too restricted or confined, unfamiliar, or out of scale or proportion.[158] Vistas should instill a comforting or cozy atmosphere. Vertical gardens can create a secure and intimate setting without being too confining. Their vertical nature ensures the maximum amount of floor area is still accessible to a user. The vegetation of vertical landscaping masks the appearance of built elements and invokes a tranquil environment. Views of vertical gardens are pleasing but generally within close proximity. If designed in a fashion that incorporates borrowed views of hills, mountains, or the ocean, the full potential of the views and vistas category can be realized.

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[157] Stephen R. Kellert, Judith H. Heerwagen, and Martin L. Mador, *Biophilic Design: The Theory, Science, and Practice of Bringing Buildings to Life* (New Jersey: John Wiley & Sons, Inc., 2008), 7.
[158] Stephen R. Kellert, Judith H. Heerwagen, and Martin L. Mador, *Biophilic Design: The Theory, Science, and Practice of Bringing Buildings to Life* (New Jersey: John Wiley & Sons, Inc., 2008), 7.

Façade greening is typically employed along either a wall or roof surface (Figure 18). Since vegetation is not normally presented in this fashion it creates interest and satisfaction. Appreciation for façade greening may stem from an inherent sense for traditional thatched roofs. Admiration of façade greening may also derive from traditional uses of vegetation as a source of insulation, camouflaging, protection, and food. More recently the healthful advantages of façade greening, or vertical gardens in general, have been examined. These green amenities provide numerous benefits to physical, mental, and social health.

Figure 18: Facade Greening on Oulu Bar, Finland[159]

Geology and landscape describes the connection between buildings and the natural geological features of the surrounding area. Successful designs arrive when building and landscape share a harmonious relation and one does not take precedence over the other. A particularly famous example is Frank Lloyd Wright's Falling Water (Figure 19). The natural surroundings would still serve as a serene example of nature, but the relationship to the house highlights the waterfall and forest context. Similarly, Falling Water shares Wright's unique Prairie-style which can be seen in many of his other designs, but the

[159] http://media.treehugger.com/assets/images/2011/10/Oulu_After.jpg

unique landscape features make it one of his most prominent works. Vertical gardens, while noticeably a manmade element, contribute to the built-nature relationship by creating a transition between both environments. While not entirely built or natural, it serves as a blending of the two.

Figure 19: Falling Water, Mill Run, Pennsylvania[160]

Habitats and ecoscapes emphasize the importance of compatibility with local habitats of any proposed design. Important ecosystems include wetlands, forests, grasslands, and watersheds.[161] Preservation of these types of habitats are vital to maintaining biodiversity and can increase the cultural value to the local population. Given the limited scale of vertical gardens, entire habitats cannot be replicated, but certain elements can still be portrayed. Selection of plants and vegetation from specific ecoscapes can contribute to replication on a small scale.

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[160] http://www.wright-house.com/frank-lloyd-wright/fallingwater-pictures/large-fallingwater-photos/high-resolution/25SW-falling-water-path2-L.jpg

[161] Stephen R. Kellert, Judith H. Heerwagen, and Martin L. Mador, *Biophilic Design: The Theory, Science, and Practice of Bringing Buildings to Life* (New Jersey: John Wiley & Sons, Inc., 2008), 8.

Fire was an essential aspect to early survival and still plays a role in modern society. In the built environment, fire has come to represent cooking and heating. Fire provides pleasing displays of color, warmth, and a means of preparing meals. Fire has not direct application to vertical gardens, but could be implemented figuratively in the form of a fire pit, fire place, or barbeque.

NATURAL SHAPES AND FORMS

Natural shapes and forms govern design elements which represent simulations of the natural world and appear in the built environment. There are eleven attributes associated with his element and they include: botanical motifs; tree and columnar supports; animal (mainly vertebrate) motifs; shells and spirals; egg, oval, and tubular forms; arches, vaults, domes; shapes resisting straight lines and right angles; simulation of natural features

- Botanical motifs
- Tree and columnar supports
- Animal (mainly vertebrate) motifs
- Shells and spirals
- Egg, oval, and tubular forms
- Arches, vaults and domes
- Shapes resisting straight lines and right angles
- Simulation of natural features
- Biomorphy
- Geomorphology
- Biomimicry

Botanical motifs are replications that take on the shapes, forms, and patterns of plants and other vegetative material that are employed as design elements in the built environment.[162] These types of symbolic representations often emulate plant forms such as foliage, ferns, cones, shrubs, and bushes (Figure 20).[163] Motifs will not only appear as literal forms but could also be metaphoric in nature. Vertical gardens could still be considered a botanical motif. The origins of modern vertical gardens are based on observations of plant-life growing on cliffs and sheer surfaces.

[162] George L. Hersey, *The Monumental Impulse: Architecture's Biological Roots* (Cambridge: MIT Press, 1999), 26.
[163] Stephen R. Kellert, Judith H. Heerwagen, and Martin L. Mador, *Biophilic Design: The Theory, Science, and Practice of Bringing Buildings to Life* (New Jersey: John Wiley & Sons, Inc., 2008), 8.

Figure 20: Tree Motif in Window Treatment, Location Unknown[164]

Tree and columnar supports reflect the traditional significance of trees serving as a source of material, food, firewood, and paper products. Trees have often been associated with stability, structural strength, and in their earliest forms, served as poles, struts, or other support roles. Representations of trees in the built environment commonly appear as columns. They can even have decorative leaf capitals to emphasize the allusion to a forest. Trees can also be metaphorically represented as in the case of the Hawaii State Capitol Building where the columnar supports were designed to emulate palm trees (Figure 21). The columns symbolize palm trees and are just one of such embedded design motifs. Vertical gardens have been used to encase columns and other structural members to portray trees or forest-like environments.

Animal (mainly vertebrate) motifs also appear in the built environment, however usually to a lesser degree than their botanical counterparts. Animal motifs generally display parts of an animal such as a head, paw, or limb rather than an entire creature. These motifs,

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[164] Stephen R. Kellert, Judith H. Heerwagen, and Martin L. Mador, *Biophilic Design: The Theory, Science, and Practice of Bringing Buildings to Life* (New Jersey: John Wiley & Sons, Inc., 2008), 264.

just like botanical motifs, can appear as highly stylized, fictionalized, or contain contorted shapes and forms.[165] Animal motifs are uncommon in vertical gardens unless displayed as a plaque or artwork.

Figure 21: Hawaii State Capitol, Honolulu, Hawaii[166]

Shells and spirals are much more organic in shape. Features can include representations of beehives, butterflies, moths, and even spider webs. While geometric forms can be replicated, shells and spirals also entail mimicry of processes. Bioclimatic controls of termite mounds, the structural integrity of seashells and hives, or the patterns of webs can all influence design elements.[167] The examination of biological processes is closely related to biomimicry which is another category of natural shapes and forms. Vertical gardens often exhibit curved and organic forms, however, shells and spirals are not typically employed because of their complex nature.

[165] Stephen R. Kellert, Judith H. Heerwagen, and Martin L. Mador, *Biophilic Design: The Theory, Science, and Practice of Bringing Buildings to Life* (New Jersey: John Wiley & Sons, Inc., 2008), 8.
[166] http://www.hawaiiforvisitors.com/images/oahu/attractions/hawaii-state-capitol-0611-400x234.jpg
[167] Stephen R. Kellert, Judith H. Heerwagen, and Martin L. Mador, *Biophilic Design: The Theory, Science, and Practice of Bringing Buildings to Life* (New Jersey: John Wiley & Sons, Inc., 2008), 8.

Egg, oval, and tubular forms are often incorporated into building facades, interiors, and landscaping. Predominantly implemented as an aesthetic component, these forms can occasionally have structural implications. Norman Foster's London City Hall serves as a prime example of a literal form doubling as the structure (Figure 22). Egg, oval, and tubular forms appear as pots or vessels in some vertical gardens, but are not a common element. Rectilinear components are much more common in vertical gardens since they are easier to stack and modulate.

Figure 22: London City Hall, London, UK[168]

Arches, vaults, and domes were utilized in the built environment to create marvelous examples of architecture, especially in Romanesque, Gothic, and Renaissance architecture. Concerning biophilic design, these elements are used to construct shells and spirals as well as other symbolic forms that replicate features found in nature. These

[168] http://www.freewebs.com/frederiekedoorn/City.hall.london.arp.jpg

components can be done for aesthetic or functional purposes. Much like the shells and spirals category, arches, vaults, and domes, appear very rarely in vertical gardens.

Shapes resisting straight lines and right angles follow the principles of nature. Rarely are natural forms straight or rigid in origin. Forms in nature are exposed to constant forces and pressure which result in curved, flowing forms. Modern buildings are generally characterized by straight edges and rectilinear geometry, but people inherently prefer organic forms and curvilinear appearances. Besides the usual rectangular border of a vertical garden, the plants and vegetation generally provide organic formations. Botanists like Patric Blanc further obscure any straight lines and right angles by designing curvilinear swaths of plants.

Simulation of natural features emphasizes simulation rather than replication of natural forms in the built environment. Forms in this category are abstracted or fictitious. Simulations are most successful if they relate to functional features occurring in nature such as shapes, patterns and processes that intimate structural integrity, and adaptive advantages in response to environmental pressures rather than simple ornamentation.[169] Vertical gardens replicate many processes and features that occur naturally in nature. The plants have the ability to absorb sunlight and heat, filter allergens and pollutants, and could conceivably purify water. Vertical gardens allude to structural integrity once plants have developed since it alludes to the use of vegetation as a means to combat erosion.

Biomorphy explains built components that do not resemble nature-inspired geometry, not even in an abstracted capacity, but are still identified as organic. Such forms thought to be products of unconscious design and are referred to as "biomorphy."[170] Biomorphic architecture can often evoke comparisons to animal or vegetative symbols though they may not have been designed to do so. Two examples of biomorphic design are Jorn

[169] Stephen R. Kellert, Judith H. Heerwagen, and Martin L. Mador, *Biophilic Design: The Theory, Science, and Practice of Bringing Buildings to Life* (New Jersey: John Wiley & Sons, Inc., 2008), 9.
[170] Gunther Feuerstein, *Biomorphic Architecture: Human and Animal Forms in Architecture* (Stuttgart: Menges, 2002), 17.

Utzon's Sydney Opera House (Figure 23) and Eero Saarinen's Yale University hockey rink (Figure 24).

Figure 23: Sydney Opera House, Sydney, Australia[171]

Figure 24: Yale University Hockey Rink, New Haven, Connecticut[172]

[171] http://upload.wikimedia.org/wikipedia/commons/4/40/Sydney_Opera_House_Sails.jpg
[172] http://a.espncdn.com/travel/091223/travel_e_ingallsrink_800.jpg

Geomorphology depicts designs successfully integrated into the surrounding landscape and geology. These types of projects often lend themselves to the environment without becoming a dominant visual force. Geomorphology can highlight natural features like rivers, waterfalls, or hillscapes and shape them into the prominent attraction of a site. Most sites take advantage of views in the distance but rarely have outstanding amenities on the property.

Biomimicry uses processes and geometry found in nature to derive structural elements. Shells, crystals, webs, mounds, and beehives have inspired numerous buildings (Figure 25). The term "biomimicry" was coined by Janine Benyus.[173] Biomimicry is a relatively new area of study but is rapidly gaining popularity and is closely linked to biophilic design. Biomimicry can dictate the support structures for vertical gardens. Façade greening trellises can utilize hexagonal shapes that give the appearance of a beehive. The angles of the hexagonal forms are superior to conventional rectilinear supports since they provide more avenues for vegetation to grow.

[173] Janine M. Benyus, *Biomimicry: Innovation Inspired by Nature* (New York: Morrow, 1997), 7.

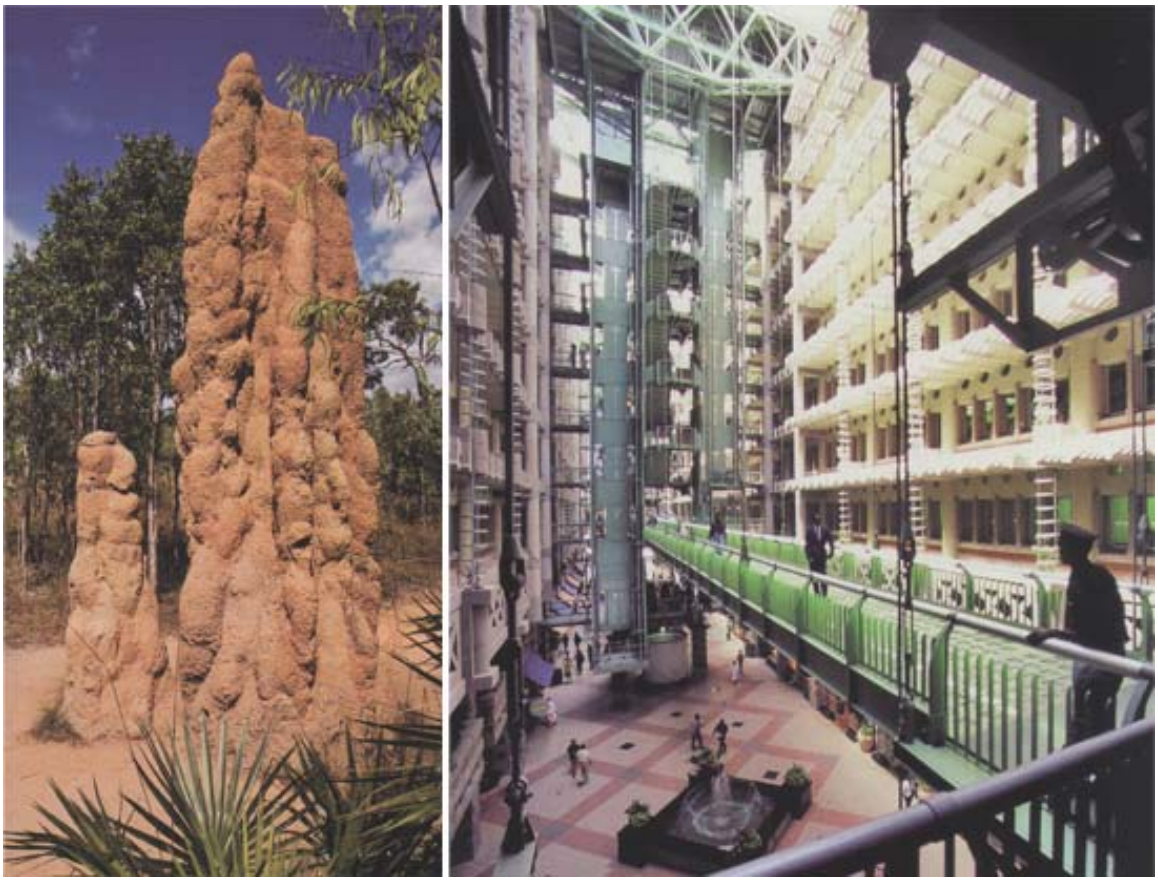

Figure 25: Temperature Self Regulating Termite Mound that Inspired Eastgate Building, Harare, Zimbabwe[174]

[174] Stephen R. Kellert, Judith H. Heerwagen, and Martin L. Mador, *Biophilic Design: The Theory, Science, and Practice of Bringing Buildings to Life* (New Jersey: John Wiley & Sons, Inc., 2008), 245.

NATURAL PATTERNS AND PROCESSES

Natural patterns and processes promote the incorporation of properties found in nature into the built environment. Fourteen attributes are associated with this element of biophilic design and they encompass:

- Sensory variability
- Information richness
- Age, change, and the patina of time
- Growth and efflorescence
- Central focal point
- Patterned wholes
- Bounded spaces
- Transitional spaces
- Linked series and chains
- Integration of parts to wholes
- Complementary contrasts
- Dynamic balance and tension
- Fractals
- Hierachically organized ratios and scales

Sensory variability describes input received through the senses and includes light, sound touch, smell, and other environmental conditions.[175] Humans have always relied on sensory input to find sources of food, avoid danger, locate shelter, and maintain modicums of comfort. In present times, sensory variability within the built environment is needed for human satisfaction and well-being and proves exceptionally productive if presented in an organized and structured fashion. Plants and vegetation selected for vertical gardens can display a wide range of colors and shapes. They can also produce a variety of smells and offer different textures.

[175] Stephen R. Kellert, Judith H. Heerwagen, and Martin L. Mador, *Biophilic Design: The Theory, Science, and Practice of Bringing Buildings to Life* (New Jersey: John Wiley & Sons, Inc., 2008), 9.

Information richness pertains to sensory input that stimulates cognitive functions. The natural world provides the most diverse environment even when compared to modern structures. Natural forms, or metaphorical representations thereof, placed in a built environment can elicit curiosity, imagination, exploration, discovery, and problem-solving.[176] Variety, texture, and detail are vital for information richness. The vegetation displayed on vertical gardens exhibit numerous shapes and variations. Leaves of a single type of plant will appear similar, but closer inspection will reveal subtle differences that prevent any two from being exactly alike. This can trigger critical thinking, analytical skills, categorization, and ordering. These features bolster cognitive development and educational theories in children. Coloring of plants offer the same intellectual stimulation. A multitude of colors are visible in the color gradations of leaves whereas the built environment tends to have flat, singular colors.

Age, change, and the patina of time are an attribute that acknowledges the dynamic progression of the natural world. Organic components tend to evoke satisfaction and a sense of emotional investment even though there is the potential for death and decay. Artificial components tend to show little wear or aging and do not instill the same sense of endearment as organic items. The passage of time is an important concept for children to grasp. Young kids often have difficulty differentiating between "tomorrow" and "a week from now" especially if expecting an event or occasion. Observing the progress of a vertical garden will help them understand the concept of time.

Growth and efflorescence are closely related to age, change and patina of time. They are both attributes that measure the passage of time and promote pleasure and satisfaction. Efflorescence reveals the maturation process of buildings and landscapes, particularly in regards to ornamentation.[177] These changes and shifts in forms, appearance, or size create a dynamic environment despite the tendency to view the built environment as largely unchanging. Vertical gardens will reveal growth as plants mature and increase in

[176] Stephen R. Kellert, Judith H. Heerwagen, and Martin L. Mador, *Biophilic Design: The Theory, Science, and Practice of Bringing Buildings to Life* (New Jersey: John Wiley & Sons, Inc., 2008), 9.
[177] Kent C. Bloomer, *The Nature of Ornament: Rhythm and Metamorphosis in Architecture* (New York: W.W. Norton, 2000), 24.

size. Efflorescence can also be displayed in support materials in the form of rust, rot, or mildew. Both growth and efflorescence help children to comprehend the value of aging.

Central focal points make navigation of the landscape easier. Much like landmarks on a map, focal points provide references that allow individuals to establish position, direction, and proximity. The built environment can appear large of scale and complex, but the addition of a central focal point can create coherence and order. Vertical gardens can serve as a central focal point since they naturally draw attention. The contrast of a natural amenity in a built environment is easily recognized.

Patterned wholes organize seemingly disparate elements to form well integrated designs. A seemingly insurmountable amount of variation is unified under a theme, style, or design aesthetic. Being able to comprehend what would be otherwise a chaotic design instills feelings of mastery and control.[178] Vegetative elements of a vertical garden differ greatly, but when composed correctly, appear ordered and organized. Modular vertical gardens form patterns by presenting green surfaces interspersed with built elements.

Bounded spaces appeal to the natural territorial instincts of mankind. Traditionally utilized to secure resources and provide safety, bounded spaces also entail ownership. Ownership leads to feelings of pride and worth. The built environment often delineates spaces with fences, walls, or enclosures. Vertical gardens help to delineate space with a much more favorable appearance than a concrete wall, metal, or wooden fence.

Transitional spaces provide relief between structures in the built environment and often allow access from one building to another. They can provide comfort by allowing individuals to move about freely. Transitional spaces include thresholds, portals, doors, bridges, and fenestration.[179] Such spaces also help to guide people through the built environment. Vertical gardens can be used to demarcate entrances, exits, and other transitional indicators. They can also be employed on large wall surfaces to provide a

[178] Stephen R. Kellert, Judith H. Heerwagen, and Martin L. Mador, *Biophilic Design: The Theory, Science, and Practice of Bringing Buildings to Life* (New Jersey: John Wiley & Sons, Inc., 2008), 10.
[179] Stephen R. Kellert, Judith H. Heerwagen, and Martin L. Mador, *Biophilic Design: The Theory, Science, and Practice of Bringing Buildings to Life* (New Jersey: John Wiley & Sons, Inc., 2008), 10.

brief respite between built elements and create a transitional area without the use of a portal or corridor.

Linked series and chains are spaces which are interconnected and have clearly demarcated paths. A long series of linked spaces is said to form a "chain." Ordered progressions through space provide a sense of organization and make wayfinding easier. If designed to do so, linked series and chains can instill curiosity and intrigue. Individuals in these types of spaces feel compelled or enticed into venturing further. Vertical gardens can be used to define a sequence of spaces. They provide an interesting backdrop for individuals traversing the adjoining path. Their verticality also allows for multiple levels to be linked by elevator cores, stairways, or other tall installations.

Integration of parts to wholes refers to the innate human preference for discrete constituent parts forming a greater whole. The comprehension of a system of parts leads to a feeling of structural integrity, particularly in complexes of considerable size and detail.[180] Being able to grasp even a few of the individual parts will allow a user to understand the greater purpose. Vertical gardens encompass multiple series of parts. They deal with several systems working in sync to sustain optimum growing conditions. Maintenance of a vertical garden deals with support systems, water and irrigation, growing medium and substrate, and selected vegetation. Modular systems add another aspect of parts since many pieces are combined to form a cohesive design.

Complementary contrasts provide necessary variation in the built environment that lead to meaning, intelligibility, and interest. Contrasts are often complementary or appear as opposites such as light and dark, high and low, or open and closed.[181] The relationship between the built and natural environments could also be considered a complementary contrast. However, excessive use of a single duality may lead to monotonous spaces or bland appearances.

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[180] Stephen R. Kellert, Judith H. Heerwagen, and Martin L. Mador, *Biophilic Design: The Theory, Science, and Practice of Bringing Buildings to Life* (New Jersey: John Wiley & Sons, Inc., 2008), 10.
[181] Stephen R. Kellert, Judith H. Heerwagen, and Martin L. Mador, *Biophilic Design: The Theory, Science, and Practice of Bringing Buildings to Life* (New Jersey: John Wiley & Sons, Inc., 2008), 10.

Dynamic balance and tension govern the dynamic relationship between contrasting forms and often fosters a sense of strength and durability in both the natural and built environments. The delicate balance between forms often transforms static components into organic-like entities.[182] The juxtaposition of dissimilar building elements can create interest and a focal point. Vertical gardens generally impose a delicate balance between the built and natural environments. Vegetation must portray an intimate feeling by being of an appropriate scale, but must contrast with built components which may be much larger. If the proper scale cannot be obtained, the vertical garden could prove too immense and feel overwhelming or intimidating. Conversely, if not pronounced enough the vertical garden will appear insignificant and may be overlooked entirely.

Fractals define the complex appearance of natural objects. While elements of the same entity may appear in great quantity they will be similar but never exact copies. Leaves of a tree will retain the same shape but small variations will prevent any two from being precise replications. These same types of similar, but non-uniform, patterns can be utilized in the built environment to provide an overarching theme but enough variation to prevent disinterest.

Hierarchically organized ratios and scales appear in an almost arithmetically or geometrically related fashion. A popular theme for these types of patterns is the Fibonacci ratio.[183] Ratios and scales cast order upon thematic situations which would otherwise seem disorganized and chaotic. Different ratios and scales can be achieved in vertical gardens based on the plant selection. Plants can range from surface covering materials, like lichen or moss, to larger shrubs and bushes.

[182] Stephen R. Kellert, Judith H. Heerwagen, and Martin L. Mador, *Biophilic Design: The Theory, Science, and Practice of Bringing Buildings to Life* (New Jersey: John Wiley & Sons, Inc., 2008), 10.
[183] Stephen R. Kellert, Judith H. Heerwagen, and Martin L. Mador, *Biophilic Design: The Theory, Science, and Practice of Bringing Buildings to Life* (New Jersey: John Wiley & Sons, Inc., 2008), 11.

LIGHT AND SPACE

Light and space describes implementation of lighting effects and their relationship to spatial qualities. There are twelve attributes linked to this biophilic element and they include:

- Natural light
- Filtered and diffused light
- Light and shadow
- Reflected light
- Light pools
- Warm light
- Light as shape and form
- Spaciousness
- Spatial variability
- Space as shape and form
- Spatial harmony
- Inside-outside space

Natural light includes the full spectrum of natural light and daylighting. Natural light has been somewhat lost in modern architecture, but is experiencing a resurgence due to biophilic design. It has been linked to physical and psychological benefits that increase productivity, health, and well-being. Much like the sunlight attribute under the environmental features element, natural light is vital to health vertical garden development. In turn, vertical gardens entice individuals to be outdoors and physically active. Outdoor activity entails exposure to natural light.

Filtered and diffused light discuss the advantages of adjusting the properties of penetrating light. In particular, filtered or diffused light can reduce glare or serve as a connection between spaces. A relationship involving indoor and outdoor spaces can be established through the manipulation of lighting conditions. Vertical gardens have the

potential to provide various levels of diffused light. Depending on the type of backing or structural material used and density of plant-life, light penetration can range from large amounts to virtually none.

Light and shadow provide a complementary contrast which elevates human satisfaction in both the natural and built environments. The juxtaposition of light and shadow can provoke curiosity, mystery and stimulation.[184] Light and shadow can also assist in determining scale, distance, proximity, and form. The shape of leaves provide interesting shadows and add a dynamic aspect when wind causes rustling of plants. Leaf profiles can create large to small shadows, and plant collections can account for large to little amounts of light penetration.

Reflected light can be bounced off colored walls, ceilings, light shelves, or even water to produce numerous lighting effects. Reflecting light of various surfaces allows light to penetrate further into interiors, reduce glare, and mitigate heat gain if the reflective surface is positioned properly. Reflected surfaces should not be of a shiny or glossy finish, but of a textured or matte color to minimize glare. Vertical gardens mainly involve heat mitigation. Since most applications are on the exterior of a building, they can significantly reduce interior temperatures by stopping heat energy before it even reaches the building.

Light pools have no involvement with water, contrary to the attribute's name. Light pools refer to collections of light in otherwise dim areas. Pools of light are very effective when employed in dark passages or hallways, or as they appear naturally in dense forests. They can instill feelings of security and protection and provide a necessary tool for navigating spaces. Skylights employed in strategically placed areas can provide light for vertical gardens and transform them into highly coveted aesthetic features.

Warm light, especially areas lit by natural sunlight, can foster feelings of a secure and inviting interior. Humans, as diurnal creatures, have a tendency to favor warmer light,

[184] Stephen R. Kellert, Judith H. Heerwagen, and Martin L. Mador, *Biophilic Design: The Theory, Science, and Practice of Bringing Buildings to Life* (New Jersey: John Wiley & Sons, Inc., 2008), 11.

even if artificial, since it is akin to the sun. Sunlight provided a means to obtain resources, travel easily, and complete daily tasks. Fire, another essential element of survival, also has red, orange, and yellow hues and further nurtures a kinship with warm light. Lamps used on indoor vertical gardens generally retain a warmer hue. They invoke connection to the outdoors and create calm and soothing environments.

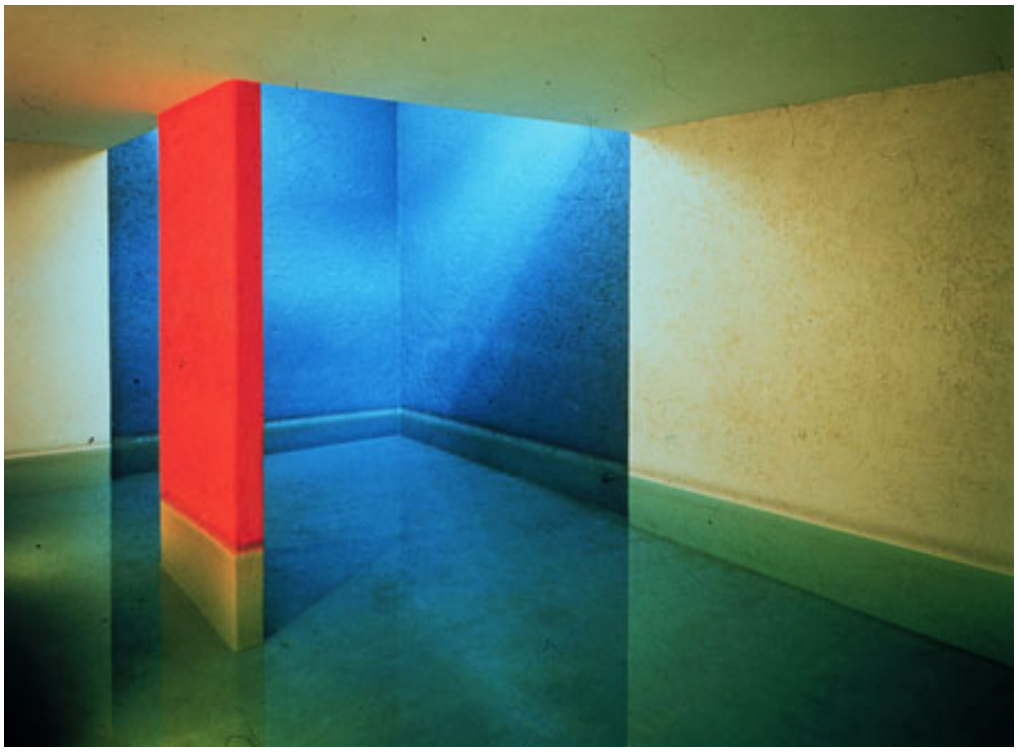

Figure 26: Girardi House, Tacubaya, Mexico[185]

Light as shape and form describes the manipulation of light to create stimulating, dynamic, and sculptural forms. Employing a single beam of light over multiple surfaces can create an intriguing point of interest. Architect Luis Barragan employed this technique with an exquisite degree of expertise (Figure 26). Not only does light provide aesthetic pleasure, but it also facilitates mobility, curiosity, imagination, exploration, and discovery.[186] If integrated efficiently, light used as shape and forms can create dynamic forms with minimal variation in built form. Natural light can create interest in a vertical

[185] http://designmuseum.org/media/item/3859/-1/1_7Lg.jpg
[186] Stephen R. Kellert, Judith H. Heerwagen, and Martin L. Mador, *Biophilic Design: The Theory, Science, and Practice of Bringing Buildings to Life* (New Jersey: John Wiley & Sons, Inc., 2008), 11.

garden. As the sun changes with the time of day, different areas of the wall will be highlighted for a dynamic appearance.

Spaciousness refers to openness in natural and built environments. Open spaces are a welcome addition when accompanied by refuge spaces. Effective designs commonly include small, interstitial spaces surrounding a large community space.[187] Buildings that incorporate this principle include airports, train stations, malls, educational facilities, and occasionally commercial facilities. Spaciousness is created by vertical gardens since they do not occupy a large floor area. They also mask the appearance of built components to further emphasize the creation of a separate space. Vertical gardens can be linked to patios, indoor areas, and other interstitial spaces.

Spatial variability necessitates the need for a diverse range of spaces. Variation of spaces should be implemented in an organized fashion to achieve emotional and intellectual stimulation. A lack of spatial diversity can lead to boredom, disinterest, and dull buildings. Exterior and interior spaces can be defined by vertical gardens. Different themes can be established through the use of separate sets of plants. These motifs create unique areas perceived as spatial variability by users.

Space as shape and form uses voids, or negative space, as a means to define forms. Much like figure-ground artwork, where subject matter and background are interchangeable, though one can take precedence over the other based on individual perception, most people will have a tendency to view physical forms as defining space rather than the other way around. Open spaces, such as atriums, can be viewed as influencing a building's physical form. Negative space can come to define vertical gardens as much as the plants and vegetation. Modular systems often use void spaces to create patterns or provide empty areas that prevent a vertical garden from becoming overwhelming.

[187] Stephen R. Kellert, Judith H. Heerwagen, and Martin L. Mador, *Biophilic Design: The Theory, Science, and Practice of Bringing Buildings to Life* (New Jersey: John Wiley & Sons, Inc., 2008), 11.

Spatial harmony depicts the manipulation of space in the built environment and it's utilization of light, mass, and scale in a successful manner.[188] Good examples of harmonious design employ all elements to provide feelings of comfort and satisfaction. All three design implications should reinforce one another without a single one taking precedence over the others. Vertical gardens maximize natural daylight. Their overall mass and scale is appropriate in regards to the surrounding context. Plants and vegetation are chosen on their aesthetic value as well as size and proportion to complement the existing scale of a building.

Inside-outside spaces achieve a blending of interior and exterior areas. Generally it connects the built environment to the surrounding natural context. Some instances can be symbolically viewed as a transition between culture and nature. Some design elements that enforce the inside-outside relation are porches, colonnades, decks, foyers, atriums, and interior gardens.[189] Views or vantage points can also promote an interior-exterior connection. Vertical gardens capitalize on indoor-outdoor relations. They can physically span from interior areas to exterior spaces. Furthermore, the juxtaposition of fabricated support structures and natural plant-life serves as the perfect transition from largely built indoor environments to more naturalistic outdoor settings.

[188] Stephen R. Kellert, Judith H. Heerwagen, and Martin L. Mador, *Biophilic Design: The Theory, Science, and Practice of Bringing Buildings to Life* (New Jersey: John Wiley & Sons, Inc., 2008), 11.
[189] Stephen R. Kellert, Judith H. Heerwagen, and Martin L. Mador, *Biophilic Design: The Theory, Science, and Practice of Bringing Buildings to Life* (New Jersey: John Wiley & Sons, Inc., 2008), 11.

PLACE-BASED RELATIONSHIPS

Place-based relationships entail successful integration of culture and ecology based on geographical context. This biophilic design element takes into consideration mankind's territorial nature and attempts to fulfill a longing for security, readily available resources, and safety. There are eleven attributes which include:

- Geographic connection to place
- Historic connection to place
- Ecological connection to place
- Cultural connection to place
- Indigenous materials
- Landscape orientation
- Landscape features that define building form
- Landscape ecology
- Integration of culture and ecology
- Spirit of place
- Avoiding placelessness

Geographic connections to place occur after an individual has attained a certain level of familiarity with the surrounding context. Certain features can be emphasized through site orientation, and views of buildings or landscapes.[190] An intimate knowledge of one's surroundings is essential for comfort, security, and predictability. Geographic connections are hard to enforce through vertical gardens. Since they are considered a fairly new technique not many have been established for substantial periods of time. Future generations may have more opportunities to feel a geographic connection to vertical gardens as they become more commonplace.

[190] Stephen R. Kellert, Judith H. Heerwagen, and Martin L. Mador, *Biophilic Design: The Theory, Science, and Practice of Bringing Buildings to Life* (New Jersey: John Wiley & Sons, Inc., 2008), 12.

Historic connections to place are derived through the passage of time and lead to a sence of participation and awareness of a particular area's culture and collective memory.[191] Natural and built environments that exist long enough to form a connection to the past, through age or events, are often viewed as important to the surrounding community. Much like geographic connections, historic connections are hard to make unless a vertical garden has existed for a substantial period of time. Several instances of façade greening in European countries may be considered historic if they were a part of the original building fabric.

Figure 27: Hagen Town Hall, Germany[192]

Ecological connections to place are established through ecological connections such as watersheds, mountains, deserts, rivers, estuaries, and oceans. A an excellent example is the Hagen Town Hall in Germany which utilizes the local river as an attractive feature (Figure 27). The built environment may infringe upon these commodities, but if

[191] Stephen R. Kellert, Judith H. Heerwagen, and Martin L. Mador, *Biophilic Design: The Theory, Science, and Practice of Bringing Buildings to Life* (New Jersey: John Wiley & Sons, Inc., 2008), 12.
[192] Stephen R. Kellert, Judith H. Heerwagen, and Martin L. Mador, *Biophilic Design: The Theory, Science, and Practice of Bringing Buildings to Life* (New Jersey: John Wiley & Sons, Inc., 2008), 248.

designed responsibly, does not have to diminish the ecological balance or biodiversity of a site.[193] All decisions made in a built environment affect the ecosystem one way or another (positive or negative) and should aim to achieve a net gain to ecological productivity. Ecological connections can be created through the incorporation of plants and vegetation found in a particular region. Vertical gardens can replicate habitats on a small scale.

Cultural connections to place involve the history, geography, and ecology of an area. These connections help to shape individual and collective identities of a particular region and form a cultural heritage. Heritage can be characterized by celebratory events, observance of holidays and occasions, and pertaining to the built environment, vernacular architecture. Cultural connections are a combination of the three previously mentioned biophilic attributes, and as such, are difficult to establish with vertical gardens.

Indigenous materials encompass local resources. Utilization of local materials reduces energy consumption, limits necessary transportation, are generally easy to manufacture, and can usually be found in abundance. The most important aspect of indigenous materials is the conveyance of cultural identity. While most modern support structures are constructed of metal framing, indigenous materials can also be utilized. Some geographic regions could use twigs or branches to create a light structure for plants to climb up. Other areas may also use fibers or reeds to weave a net-like material that when draped over vertical surfaces will allow for plants to grow on.

Landscape orientation examines the ability of buildings and landscapes to successfully contribute to a sense of place. Such designs focus on features like slope, aspect, sunlight, wind direction, and capitalize on existing biometeorological conditions.[194] Good examples of landscape orientation seamlessly integrate buildings and landscape into the

[193] Stephen R. Kellert, Judith H. Heerwagen, and Martin L. Mador, *Biophilic Design: The Theory, Science, and Practice of Bringing Buildings to Life* (New Jersey: John Wiley & Sons, Inc., 2008), 12.
[194] Stephen R. Kellert, Judith H. Heerwagen, and Martin L. Mador, *Biophilic Design: The Theory, Science, and Practice of Bringing Buildings to Life* (New Jersey: John Wiley & Sons, Inc., 2008), 12.

local culture. Vertical gardens must consider several landscape orientation issues. They must regard the sun's path, prevailing winds, soil conditions, and existing views.

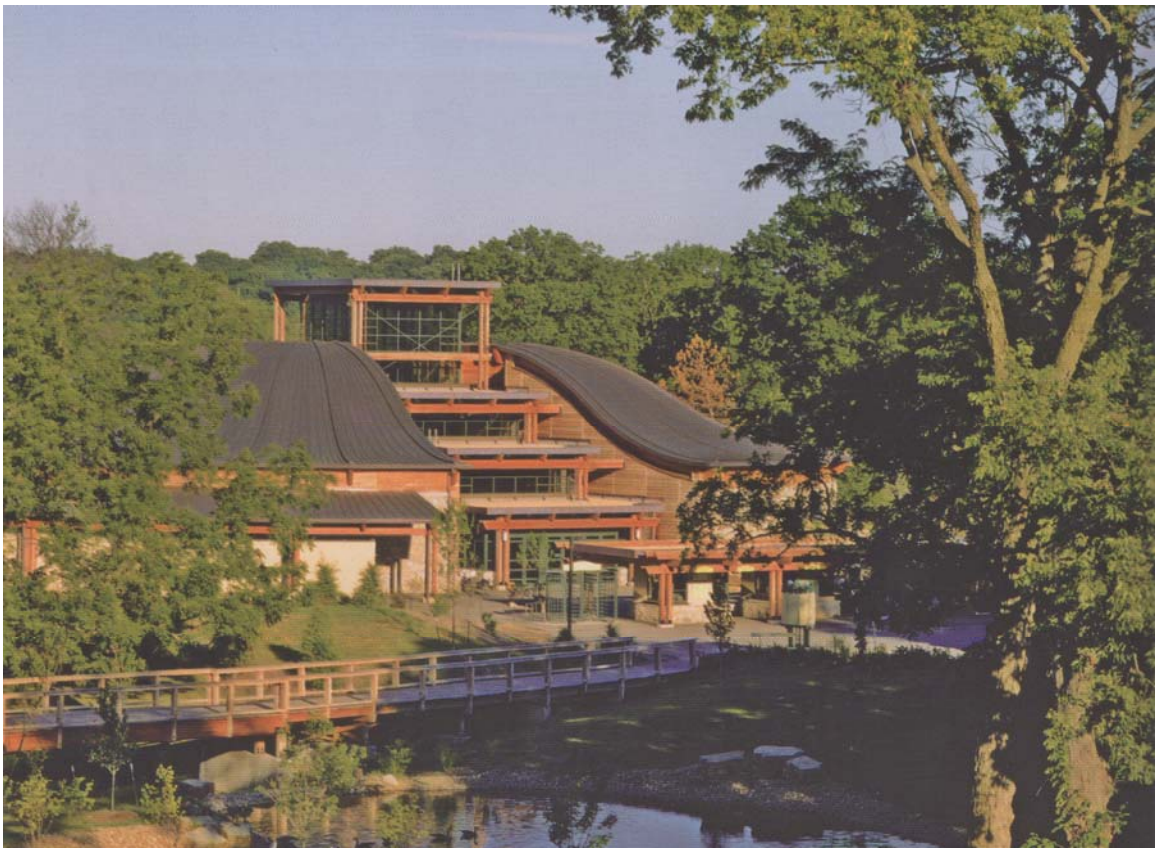

Figure 28: Deramus Educational Pavilion at the Kansas City Zoo, Kansas City, Missouri[195]

Landscape features that define building form consist of geological components playing a prominent role in the site context. These include hills, slopes, formations, natural objects, and water features. A sterling example is the Deramus Educational Pavilion at the Kansas City Zoo (Figure 28). The building was designed to sit nestled in the natural valley and invite sunlight and water into the structure. Buildings or landscapes with significant integration of natural components rarely appear isolated or foreign within the surroundings. Frank Lloyd Wright once said:

[195] Stephen R. Kellert, Judith H. Heerwagen, and Martin L. Mador, *Biophilic Design: The Theory, Science, and Practice of Bringing Buildings to Life* (New Jersey: John Wiley & Sons, Inc., 2008), 272

> "No house should ever be built on a hill. It should be of the hill, belonging to it, so hill and house could live together each the happier for the other.[196]"

Vertical gardens can enhance the relationship between building and natural site amenity. Should no notable site features exist, the vertical wall itself could become the prominent landscape feature.

Landscape ecology focuses on retaining long-term ecological functions. Prominent designs will consider landscape structure, pattern, and processes such as ecological connectivity, biological corridors, resource flows, biodiversity, optimal scale and size, ecological boundaries, and other parameters of functioning natural systems.[197] Vertical gardens can mimic natural functions. They can be employed for water recollection and filtration and serve as connections between other landscaped environments. In urban environments, they serve as the first step to reestablishing biodiversity and ecological boundaries.

Integration of culture and ecology describes the fusion of nature and humanity to form a mutually beneficial association. Buildings or landscapes of this type instill loyalty, responsibility, and stewardship among the residents nearby.[198] Vertical gardens can affirm cultural connections through the use of native and indigenous plant species. They have the capacity to grow medicinal herbs, edible produce, or cultivate rare species. The plants chosen also enforce the local ecology.

Spirit of place signifies the responsibility and enjoyment people take from valued elements of the natural and built environment. Buildings and landscapes become more than inanimate objects and are often given a "life" of their own. The spirit of a place enhances the feelings of responsibility and stewardship that may already exist from a site being a part of the individual or collective identity of an area. The presence of vertical

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[196] Andy Wasowski and Sally Wasowski, *Building Inside Nature's Envelope: How New Construction and Land Preservation Can Work Together* (New York: Oxford University Press, 2000), 47.
[197] Wenche Dramstad, *Landscape Ecology Principles in Landscape Architecture and Land-Use Planning* (Washington D.C.: Island Press, 1996), 19-40.
[198] Stephen R. Kellert, Judith H. Heerwagen, and Martin L. Mador, *Biophilic Design: The Theory, Science, and Practice of Bringing Buildings to Life* (New Jersey: John Wiley & Sons, Inc., 2008), 13.

gardens provide much needed contrast in built environments and are favored for their naturalist appearance. They can invoke feeling of relaxation, joy, and in some instances, euphoria. Such feelings lead individuals to value vertical gardens and take emotional stock in their growth and development.

Avoiding placelessness should be a major goal of any place-based design. "Placelessness" entails areas that have no significant identity and is unfortunately becoming an increasingly common affair in modern architecture. No longer do structures aim to portray vernacular architecture but rather present a uniformed modern look with little cultural ties. Furthermore, buildings are increasingly building out to a maximum footprint and decreasing the amount of natural environment available. This has led to a sharp decline in human-nature relationships.

EVOLVED HUMAN-NATURE RELATIONSHIPS

Evolved human-nature relationships differ from the other elements in that it does not describe biologically based affinities for the natural environment, but rather aspects of the inherent human relationship to nature. There are twelve attributes to this element and they are:

- Prospect and refuge
- Order and complexity
- Curiosity and enticement
- Change and metamorphosis
- Security and protection
- Mastery and control
- Affection and attachment
- Attraction and beauty
- Exploration and discovery
- Information and cognition
- Fear and awe
- Reverence and spirituality

Prospect and refuge are integral parts to human-nature relationships. Humans, by nature, favor edge settings, which are environments on the border between open and closed areas.[199] The enclosed space provides refuge while the view to the open space creates a prospect. A prospect provides a vantage point for viewing across great distances. Refuge denotes a structure or area in the natural environment which provides a feeling of security and place of respite. In the buildings, a refuge often appears on the interior in the form of a courtyard or other comparable comforting space. Though the concept of a prospect does not typically apply to a vertical garden, they do have the potential to act as a refuge.

[199] Dak Kopec, *Environmental Psychology for Design* (China: Fairchild Publications, 2006), 94.

Vertical landscapes provide a secure, tranquil environment for relaxing or physical activities.

Order and complexity are interrelated tenets. Order transposes organization into the natural or built environment. Order to the point of understanding, but attempting to control every aspect of the surrounding area can result in repetition, monotony, and boredom.[200] Complexity governs detail and variation. A nominal amount of complexity is required to create interest, but too much diversity results in frustration and angst when trying to understand an environment. When order and complexity are employed in a complementary fashion there are enough unique characteristics to promote curiosity and admiration. Vertical gardens are a sterling example of order and complexity. Order appears in the geometrical surfaces that normally constrain the growing area for vegetation. Order is further emphasized in modular systems with standardized units. Complexity is achieved through variation of plants. The natural growth of vegetation provides organic shapes and formations.

Curiosity and enticement encourage and nurture the human need for exploration, discovery, mystery, creativity, all of which are vital to problem solving.[201] These interrelated qualities also help individuals develop risk-taking, independence, self-confidence, and self-esteem. Vertical gardens are thought provoking due to landscape being employed in an atypical fashion and should prompt children to follow inventive lines of thinking.

Change and metamorphosis describe maturation, growth, and transformation as constant forces in the built and natural environment. Successful designs of buildings and landscapes implement these dynamic changes and showcase them as prominent features. The changes over time implicate a unique relationship as different components will transform at various rates. Plants chosen for a vertical garden will boast different rates of

[200] Stephen R. Kellert, Judith H. Heerwagen, and Martin L. Mador, *Biophilic Design: The Theory, Science, and Practice of Bringing Buildings to Life* (New Jersey: John Wiley & Sons, Inc., 2008), 13.
[201] Stephen R. Kellert, Judith H. Heerwagen, and Martin L. Mador, *Biophilic Design: The Theory, Science, and Practice of Bringing Buildings to Life* (New Jersey: John Wiley & Sons, Inc., 2008), 13.

growth. Some will exhibit rapid growth while others will develop at a much slower pace. Children will not only learn about the progression of time, but that it affects different entities in various ways.

Security and protection are fundamental needs of mankind. They should not be achieved at the expense of other design elements. A building or landscape must provide an adequate feeling of safety without completely isolating individuals from the outside environment. Vertical gardens can serve as boundaries and are more than adequate at instilling a sense of protection and safety.

Mastery and control are innate human desires. The built environment tends to exert human dominance over the natural conditions. Sites can be graded, hills leveled, streams and rivers, diverted, and trees torn down, but all to the detriment of a productive biophilic design. When done in moderation, to achieve a satisfactory design, control over the surrounding environment can foster feelings of ingenuity, self-confidence, and accomplishment. All aspects of a vertical garden allow a certain level of human control. The growing surface is predetermined by design, the amount of water plants receive is regulated, and maintenance of plant-life is dictated by as much human intervention as desired.

Affection and attachment for the natural world are important to establishing an appreciation for nature. Affection for the natural environment has also led to effective bonding between humans and cultures. Buildings that display a strong affinity to nature generally elicit long lasting loyalty and commitment from occupants.[202] The reoccurring theme of time allows children to observe the progress of plants on a vertical garden. The longer they are able to view a plant's progress the more effort they will invest in its well-being. This will translate to affection and attachment for animals and other human beings as well.

[202] Stephen R. Kellert, Judith H. Heerwagen, and Martin L. Mador, *Biophilic Design: The Theory, Science, and Practice of Bringing Buildings to Life* (New Jersey: John Wiley & Sons, Inc., 2008), 14.

Attraction and beauty focus on the aesthetics of a human-nature relationship. Humans have an innate fondness for nature and its ability to captivate attention. Attraction to the natural environment has been linked to improved creativity, imagination, exploration, and even problem solving.[203] Some of the most notable examples of buildings and landscapes display an obvious appreciation for the aesthetic value of nature.

Exploration and discovery are essential for experiencing the natural world. Buildings and landscapes that provide opportunities for exploration and discovery are very successful in stimulating interest and appreciation. Even symbolic or metaphoric representations of natural processes have a proclivity to promote intellectual stimulation. Naturalistic traits of vertical gardens encourage exploration and interaction from children. A diverse range of vegetation adds another dimension of interest if many colors and shapes are presented. Even alluring smells can be designed into a vertical garden.

Information and cognition can be drawn from environments that exhibit a diverse range of natural forms and shapes. The organic forms of nature force individuals to make comparisons and connections to previous experience and can increase problem solving and critical thinking. These experiences with nature can be direct, indirect, or symbolic. Symbolic experiences can include ornamentation or patterns on buildings or in landscapes that reflect organic objects. Vertical gardens represent indirect experience. In urban or suburban environments, indirect experience is likely the highest achievable setting and will still provide invaluable interaction to foster a human-nature relationship.

Fear and awe may seem strange to highlight as an advantageous attribute, but it does have merit. Fear can lead to caution which can be healthy. Caution alerts individuals of danger and allows for safe interaction with the natural environment. Fear can also lead to safety measures being implemented into the built environment and careful consideration paid to site conditions. Awe can create a reverence for nature and lead to a healthy respect for phenomena that could never be replicated by human means.

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[203] Stephen R. Kellert, Judith H. Heerwagen, and Martin L. Mador, *Biophilic Design: The Theory, Science, and Practice of Bringing Buildings to Life* (New Jersey: John Wiley & Sons, Inc., 2008), 14.

Reverence and spirituality are reinforced through nature. Humans harbor a need to define and affirm creation. Buildings and landscapes that successfully highlight nature's splendors can evoke feelings of transcendence.[204] Structures or landscapes of this type are often maintained and looked after for extensive periods of time. Vertical gardens foster an individual's innate love of nature. This love of nature translates to an appreciation of landscapes like Yosemite Park, Niagra Falls, and other impressive landscapes. Awe of such sites strengthens spirituality and inspires reverence for natural forces.

[204] Stephen R. Kellert, Judith H. Heerwagen, and Martin L. Mador, *Biophilic Design: The Theory, Science, and Practice of Bringing Buildings to Life* (New Jersey: John Wiley & Sons, Inc., 2008), 14.

9.3 ADVANTAGES OF UTILIZING BIOPHILIC ATTRIBUTES

The biophilic dimensions, elements, and attributes govern different aspects of the built environment, but all provide insight as to favorable qualities that humans look for. They also help to nurture the innate human-nature connection which people long for but may not be cognizant of. The more principles engaged by a design, the higher the level of human comfort. The biophilic attributes serve as great evaluative criteria for examining healthy child-rearing environments. They can determine the potential of an area to reinforce educational theories, transfer, all facets of childhood development, and promote better health and well-being.

Environmental features like color, water, sunlight, plants, animals, and natural materials supply a variety of sensory input that serve as a catalyst for all educational theories. These allow children to form concepts and notions about their surroundings. Eventually youths will learn to recognize reoccurring themes in regards to natural shapes and forms. They will comprehend botanical motifs; egg, oval, and tubular forms; arches, vaults, and domes; geomorphy; and biomimicry. Biophilic design attributes can also account for cognitive educational theories. While predominantly thought to encompass studying, textbooks, and instructional settings, many factors of the natural environment complement cognitive functions. Natural patterns and processes like sensory variability, patterned wholes, complementary contrasts, and linked series and chains can prompt increases in memory retention, categorization skills, and hierarchical ordering.

Behavioral, functionalist, and constructivist educational theories benefit from biophilic traits like curiosity and enticement; exploration and discovery; prospect and refuge; and transitional spaces. They appeal to a child's inquisitiveness and encourage outdoor play. Children who spend more time outdoors develop physical characteristics like stamina, strength, and agility. Physical activity combats sedentary behavior, which is an unfavorable quality more and more children are prone to.

These traits, by supporting educational theories, translate to improved childhood development. All three facets of childhood development; cognitive, affective, and

evaluative; benefit from the incorporation of biophilic attributes. As previously mentioned, biophilic design provides much more variation and diversity than typical built environments, and in turn, enhances cognitive functions. Affective development is supported by concepts of light and space such as natural light, warm light, light as shape and form, and spatial variability. Inclusion of even a few of these tenets can improve demeanor, attitude, and overall well-bring. Evaluative development draws from all elements of biophlic design to cultivate a child's ability to form values. Traits like mastery and control, the patina of time, reverence and spirituality, landscape ecology, and historic connection to place encourage kids to formulate concepts and notions about the world around them. Children also learn to harbor affection, attachment, and make emotional investments in other living objects.

Biophilic design not only ensures better child development but also boasts healthful advantages that will last through adulthood. Addition of biophilic elements like light and space, environmental features, place-based relationships, and evolved-human relationships can improve physical, mental, and social health. They can be applied to various settings including the workplace, residences, educational facilities, or even industrial areas. Biophilic traits can enhance physical health by lowering blood pressure and muscle tension, elevate mental health by reducing stress and boosting attentiveness, and foster social health by encouraging cooperation and collaboration.

10.0 VERTICAL GARDENS

Vertical gardens are an innovative technique that is rapidly gaining popularity. They create a seamless blend between the natural and built environments. The potential for developing vertical gardens is immense since it offers a type of self-regenerating cladding system. Although only recently gaining a lot of attention, the practice has been commonplace in European countries in the form of facade greening for several decades. Self-clinging climbers with roots or suckers were originally used in these types of applications since they required no additional structures for support. Transitioning from traditional practices to modern vertical gardens has witnessed the incorporation of steel cables, mesh material, or trellis type structures. While traditional methods allow vegetation to grow directly on a building surface, modern day treatments favor bringing the plants off the walls.

The customary use of vines and climbers in an architectural context was to cool the sides of buildings during the summer. They were also used to envelope pergola type structures for shading purposes. Along with the cooling benefits, climbers also offered a way of screening utilitarian structures such as garages, storage sheds, and even outhouses. Although beneficial and aesthetically pleasing, traditional facade greening was rarely ever used on a larger scale. Most buildings that employed climbers were one-story residential buildings or smaller accessory structures. They were never used to cover large commercial or industrial facades, and certainly, covering any building more than several stories high was not a consideration.

During the early twentieth century, climbers were used quite extensively in German-speaking countries. This spur in facade greening was mainly attributed to the Art Nouveau movement and its emphasis on integration of home and garden. A similar trend also occurred in Britain during the same period. The British applied climbers and vines particularly to pergolas and other structures found predominantly in public parks and rest areas, whereas German-speaking countries, and a few places in France, used them rather extensively on residential and low-rise buildings. There was a decline in facade greening

starting in 1930 and continuing in the ensuing years. It wasn't until recent years that the technique began to recover its popularity.

Vertical gardens are a relatively new practice, or can be considered an old one that resurfaced, and generally requires substantial planning before implementation. While ideation and development does take considerable time, actual construction of such projects has been made easier through new support materials. These structures are available from an ever-increasing network of international manufacturers and distributors. Since resources are readily obtainable, vertical gardens are quickly becoming a realistic and viable option. While there are some who are adamantly against vertical gardens, their opinions generally stem from experiences where vegetation directly on the side of a structure may have imposed damage to the building. With the wide range of supports now available, all climbers and plants can be kept out of direct contact with the building and can change the naysayers to avid admirers.

For the purpose of this project, vertical gardens have been divided into three classifications: façade greening, planter walls, and green walls. All three share common advantages and benefits which will be discussed in the next section. Each type of wall will be evaluated based on its own individual merit and will be discussed in the forthcoming sections. Their different means of construction, vegetation, and application will be explained and case studies provided to create a better understanding. An evaluation of the biophilic principles each vertical garden displays or could potentially utilize will be conducted and a score based on the number of biophilic traits will be tallied. The vertical garden with the highest score will be deemed the best for childhood development and serve as the basis for design implications of a modular system.

10.1 COMMON ADVANTAGES AND BENEFITS

Vertical gardens reintroduce nature into urban and suburban environments, offset carbon emissions, reduce energy consumption, and retain stormwater.[205] Vertical gardens can potentially be more beneficial than green roofs. The amount of surface area attributed to walls is generally substantially larger than the amount of roof area. In multi-story buildings, the ratio is even more evident. Innovation in support structure systems will surely allow climbers and vines to cover the expanse of structures several stories high. Furthermore, vegetation on the facade can potentially be trained to grow back over the roof and cover even more of the building's surface.

Greening of facades can drastically reduce the heat a building absorbs by shading areas exposed to the sun for extended amounts of time. This can reduce the amount of temperature fluctuation experienced within the building by as much as 50 percent. Temperature variations near the wall can be brought down from a 50 degree Celsius change to a 25 degree Celsius difference. Vertical gardens can be more effective than standard radiant barrier techniques since its exterior application prevents the sun from hitting the building directly and therefore mitigates the heat before it even enters the building. A simple 5.5 degree Celsius reduction in exterior wall temperature can reduce the energy required for air conditioning by as much as 50-70 percent.[206]

Vertical gardens are most effective when employed on the wall facing the sun and also on the western wall exposed to afternoon heating. Vegetation in no way inhibits the function of windows. They can be trained and maintained to grow around openings and can even be used to shade them seasonally. Much like an awning or other shading device, plants will significantly reduce the amount of solar energy that enters the building. Additionally, the leaves of any plant will absorb more energy than typical fabric or solid materials of traditional awnings.

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[205] Timothy Beatley, *Biophilic Cities: Integrating Nature into Urban Design and Planning* (Washington D.C.: Island Press, 2011), 122.
[206] Nigel Dunnett and Noel Kingsbury, *Planting Green Roofs and Living Walls* (Portland: Timber Press, 2004), 130.

While the mitigation of heat is generally the best known advantage of vertical gardens, it also prevents heat loss during the winter season. Employing plant life on walls receiving little to no sun provides insulation by maintaining a curtain of air between the vegetation and structure. The thickness, along with the density, of any plant material generally determines its effectiveness as an insulator. The optimum thickness for facade vegetation is 8-16 inches.[207] An older group of flora usually produces better insulative values, however it depends on the species. Several plants provide better temperature regulation with age, but after a certain point, their growing habits change and they actually lose some efficiency. Approximately one-third of a home's heating requirements during the winter is attributed to wind chill. In areas where cold winds are prevalent, the main source of heat loss is the cooling of exterior walls. Reducing wind chill by 75 percent can alleviate the energy demand for heating by 25 percent.[208]

Aside from regulating temperatures, vertical gardens provide other benefits. Climbers utilized in urban areas are useful in trapping dust and other microbial pollutants. Once absorbed it is usually stored in the leaves which are eventually discarded over the lifetime of the plant. The ability of plants to trap dust and pollutants is directly related to the surface area of its leaves. A leaf index is a measurement of the leaf surface area compared to the wall area. The higher the index, the more effective it is at collecting dust.[209] Along with collecting pollutants, the surface area of leaves also reduce the amount of ultraviolet light directly hitting the wall surface, and in turn, prevent damage and fading to wall cladding material. Plants also protect the surface from rain and hail, in areas where they occur. Vertical gardens can significantly increase the biodiversity of dense urban areas. While promoting wildlife is ecologically responsible it should not reach the point where insects and animals inhibit the growth and development of the plant life.

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[207] Nigel Dunnett and Noel Kingsbury, *Planting Green Roofs and Living Walls* (Portland: Timber Press, 2004), 131.
[208] Nigel Dunnett and Noel Kingsbury, *Planting Green Roofs and Living Walls* (Portland: Timber Press, 2004), 131.
[209] Nigel Dunnett and Noel Kingsbury, *Planting Green Roofs and Living Walls* (Portland: Timber Press, 2004), 132.

11.0 FAÇADE GREENING

Façade greening was traditionally the most common type of vertical garden. It could be considered the origin of vertical gardening and generally employs climbers or vines. Facade greening differs from other green walls since the plants commonly grow from the ground level. They are usually self-clinging or use a light support structure. Bearing elements fall into three categories: trellis structures, composed of vertical and horizontal members, horizontal, or vertical structures. While the vegetation itself certainly adds an aesthetic value, the support structures can also emphasize or accentuate existing architectural features. While many applications provide supports to promote upward growth, facade greening can develop in a top-down fashion also. They can be planted above retaining walls or from a provided planter. Some species, such as *Jasminium officianale*, can hang to a maximum length of 5 meters (17 feet).[210] If combined with species that grow from the ground up, a nice blend can be created where the two meet.

There are numerous plants that can be used for the purposes of facade greening. Most climbers employ small roots that originate from the stem. They are particularly effective at latching on to coarse surfaces. Stone, brick, or cement provide excellent growing planes, whereas shiny smooth surfaces like metal, polished stone, or acrylics make for poor surfaces. Buildings covered with plaster or whitewash retain a brittle, powdery texture and are usually not the best for climber growth.[211] Brick and mortar, as well as tiled walls, run the risk of roots penetrating deep into the crevices and causing damage to the building. Brightly painted surfaces, especially highly reflective ones, can inhibit the development of climbers.

[210] Nigel Dunnett and Noel Kingsbury, *Planting Green Roofs and Living Walls* (Portland: Timber Press, 2004), 144.
[211] Nigel Dunnett and Noel Kingsbury, *Planting Green Roofs and Living Walls* (Portland: Timber Press, 2004), 140.

SELF-CLINGING CLIMBERS

Self-clinging climbers have been widely used and are favored for their ability to creep up facades without the aid of support structures. Several popular climber species are *Parthenocissus, Hedera, Euonymus,* and *Hydrangea*. Each species is valued for different reasons and vary in aesthetics, growing habits, and ability to thrive in diverse lighting conditions. Self-clinging climbers are able to achieve staggering amounts of growth contrary to what most people may believe. *Hedera helix*, better known as common ivy, is capable of reaching a height of 30 meters (98 feet) and can comfortably cover 600 square meters (6,500 square feet).[212]

Some self-clingers, such as *Parthenocissus*, utilize a glue-like substance to attach tiny tendrils on the growing surface. Unlike aerial roots of other vines, they will not cause damage to walls by entrenching themselves into seams. This gives them the ability to expand across smooth and slick materials, however there is a tradeoff. The sticky appendages cannot support the same weight as roots that burrow themselves into the interstices of a facade. If the plant's weight becomes too great, the climbers may start peeling away from the surface.

Majority of self-clinging climbers demonstrate phototropism, which is the tendency to grow towards the light. This habit tends to force them to grow vertically. While some facade greening plants can be coaxed into growing in a certain direction by simply attaching their stems to supports, self-clingers typically fail to attach themselves if stems are forced away from the light. The flexibility of climbers varies between species. *Parthenocissus tricuspidata* tends to grow downward on a sunny wall and is capable of growing sideways over long expanses, whereas *Hedera* have a propensity to form an

[212] Nigel Dunnett and Noel Kingsbury, *Planting Green Roofs and Living Walls* (Portland: Timber Press, 2004), 139.

inverted triangle.[213] In order to encourage growth over open spans, wire mesh or a trellis assembly can be implemented.

TWINING CLIMBERS

These types of climbers have a strong inclination to grow vertically. They can be forced to grow horizontally but require frequent maintenance in the form of tying down branching portions. Twining climbers have a large assortment of sizes. Despite the amount of work attributed to making these type of climbers grow horizontally, many people find it worthwhile to cultivate *Wisteria*, which have a charming lavender flower. Once full grown, the branches can range from skinny twigs to small tree trunks. The vertical growth pattern and sizable nature of twining climbers calls for vertical supports for optimum development. Bearing elements must be constructed of durable materials like steel or fiberglass and should be round with a diameter between 4-30 millimeters (0.2-1.2 inches).[214] The strength of the support structure material is important since twining climbers could exert a twisting force along them. Tension cables should also be tightened annually to ensure integrity.

TENDRIL AND LEAF-TWINING CLIMBERS

Tendril climbers are vines in the truest sense. The stems of the leaves wrap themselves around available surfaces in order to continue growing upward. Nature provides trees and branches for tendril climbers to secure themselves, but the built environment necessitates the need for support elements. Trellis supports are the most common as they make use of both vertical and horizontal members. Both lateral and vertical supports should intersect every 10-20 centimeters (4-8 inches) for smaller tendril climbers like *Clematis* variations, but can be spaced every 25-50 centimeters (10-20 inches) for larger

[213] Nigel Dunnett and Noel Kingsbury, *Planting Green Roofs and Living Walls* (Portland: Timber Press, 2004), 141.
[214] Nigel Dunnett and Noel Kingsbury, *Planting Green Roofs and Living Walls* (Portland: Timber Press, 2004), 142.

species like *Vitis*.[215] While most leaf-twining climbers favor a vertical and horizontal layout, some thrive better on diagonally oriented trellis supports.

RAMBLERS AND SCRAMBLERS

These types of facade greening vegetation are not really vines or climbers since they do not attach themselves with roots or suckers. Ramblers and scramblers usually rely on thorns as a way to grasp other plants. Their lack of attachment appendages makes them poor candidates for following artificial supports. If no other vegetation is present to cling to, they normally grow into dense low-lying brush. Should there be plants available to guide a rambler or scrambler, they grow in a rather chaotic fashion. Variations with no thorns, such as *Plumbago capensis*, have no means at all to secure themselves and can only rest on supports.[216] Just like twining climbers, ramblers and scramblers require much tying and securing to supports in order to grow successfully. Spacing for rambler bearing elements should be between 25-50 centimeters (10-20 inches), but since they have a propensity to cover horizontal spans better, walls with a low overall height can have supports with a vertical spacing of 40 centimeters (16 inches).[217]

ANNUALS

Annual climbers must be used selectively and can grow to considerable size in just a year. They are good at providing temporary coverage until the other climbers can fully mature. Some species, like *Cobaea scandens*, may be used but care must be taken to ensure that annuals do not overwhelm other climbers as they are trying to establish themselves.[218] Annuals serve a more permanent function in areas utilized during the warmer seasons. They have the potential to provide adequate shading for porches, decks,

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[215] Nigel Dunnett and Noel Kingsbury, *Planting Green Roofs and Living Walls* (Portland: Timber Press, 2004), 143.
[216] Nigel Dunnett and Noel Kingsbury, *Planting Green Roofs and Living Walls* (Portland: Timber Press, 2004), 143.
[217] Nigel Dunnett and Noel Kingsbury, *Planting Green Roofs and Living Walls* (Portland: Timber Press, 2004), 143.
[218] Nigel Dunnett and Noel Kingsbury, *Planting Green Roofs and Living Walls* (Portland: Timber Press, 2004), 143.

and terraces, and in the winter when they lose their leaves, it is inconsequential since outdoor areas are rarely used. In warm climate zones, annuals can achieve a considerable amount of growth and provide much needed shade for cooling purposes.

OTHER PLANTS

Some plant life used in facade greening is not directly applied to the surface. Wall shrubs make a complementary addition to any vines and climbers used. Rooted on the ground plane, they can be trained to grow along the wall. There is no direct attachment as in the case of most facade greening vegetation. Wall shrubs can fulfill much the same role as climbers since they can eventually be maintained to cover large portions of a facade. They are limited to the height they can reach and rarely achieve a vertical size of more than two-stories. Unlike most facade greening plants, wall shrubs normally require little supports and guides if any at all. Some wall shrubs, *Picea omorika* for example, are planted close to the exterior walls of dwellings to act as a windbreak.[219] Most shrubs adapt well to shallow soil depths and narrow planters.

SUPPORT STRUCTURE CONSTRUCTION

When determining how to construct the support structure for a facade greening project, the most important consideration is the type of vegetation implemented after installation. Some types of plants will require only vertical supports. These types often provide the best design solution and have minimal visual impact on a building, however, if the plant selection necessitates it, horizontal members must be incorporated as well. Along with the climbing habits of the plants, size, plant vigor, and climatic variables must be taken into consideration.

[219] Nigel Dunnett and Noel Kingsbury, *Planting Green Roofs and Living Walls* (Portland: Timber Press, 2004), 145.

CLIMBING HABITS AND SIZE

Several species of climbers can exert a large amount of force as they entwine themselves around support structures. In these instances, cables and tensile supports may not be the suitable choice. The climbing habits of a plant determine the spacing necessary in any support structure. Stronger vines can manage with larger spacing while less vigorous ones need smaller gaps between supporting members. Weaker plants need vertical supports spaced 20-40 centimeters (8-16 inches) apart or lattices of 15 x 25 centimeters (6 x 10 inches). Stronger climbers are satisfied with supports 40-80 centimeters (16-32 inches) apart or lattices of approximately 30 x 40 centimeters (12 x 16 inches).[220] The distance between the support structure and the wall it is set on depends on the thickness of the plant stems. It should be at least 2 centimeters (0.78 inches) greater than the thickest stem portion. Specific examples include 10 centimeters (4 inches) for thin stemmed plants like *Akebia*, *Clematis*, and *Lonicera*, 15 centimeters (6 inches) for thick stems such as *Actinidia* and *Vitis*, and 20 centimeters (8 inches) for branch-like stems as seen in *Celastrus* and *Wisteria*.[221]

CLIMATIC FACTORS

There are numerous climatic factors that must be taken into consideration when selecting a support system. Rainfall and wind are the main concerns, and snow where applicable. Facade greening plants can range from 1-50 kilograms per square meter (0.09-4.5 pounds per square foot) and rain and snow loading can double and even triple these figures. Wind loads are derived from the direct pressure, turbulence, and suction applied. Climbers with small and thin profiles experience less stress. Plants with larger cross-sections or dense leaf development are subjected to added wind loads, which is then transferred to the support structure.

[220] Nigel Dunnett and Noel Kingsbury, *Planting Green Roofs and Living Walls* (Portland: Timber Press, 2004), 152.
[221] Nigel Dunnett and Noel Kingsbury, *Planting Green Roofs and Living Walls* (Portland: Timber Press, 2004), 152.

For general designing the following figures can be used as basic values: about 0.5 kilonewtons per square meter at heights up to 8 meters (26.4 feet), 0.8 kilonewtons per square meter between 8-20 meters (26.4-66 feet), and 1.1 kilonewtons per square meter for heights above 20 meters. If they entire load is taken by the supports then the upper portion must be able to bear the entire load plus half the wind load, whereas the lower supports only need to cover half the wind load.[222]

11.1 SUPPORT STRUCTURES

There are various types of vertical supports and each type transfers the loads of facade greening to different areas. Direct load transference is a very common method. It utilizes a rigid frame, attached at regular intervals to the facade, to ensure uniform load distribution. The supports can be upheld by a few strong members or by many weaker ones.

A rigid frame can also be hung from a point near the top of the building. It is attached at regular intervals along the lower extends, but mainly for lateral stability and not to assist in the vertical loads. The hanging method also allows for the framing to be placed further off the wall and ensures a good deal of airspace between the building and eventual plant coverage. Conversely, a rigid frame can also be anchored into the ground if there is adequate soil or a concrete foundation. The frame is secured the building at multiple points along its vertical span in order to stabilize it against lateral forces like wind. If the building itself is strong enough to support the load of facade greening, the bottom of the rigid frame can be tied into the base of the building rather than the ground. Similar to the hanging system, since the loads are mainly carried by a single point of connection, they are ideal for situations where facade greening is applied to non-bearing walls.

Tensile structures are also an option as vertical supports. They are ideal in situations where minimal points are available to secure a rigid frame. They are essentially tied into

[222] *Green Solutions G1*, Jakob AG Switzerland. Jakob Catalog, http://www.jakob.co.uk/images/stories/JakobAssets/pdf/Green_G1_full_UK.pdf

the building at the top and bottom and stretched over the length of it. Intermediate fixings are added for lateral stability and to secure intersecting points between vertical and horizontal cables. They are slowly becoming more prevalent since they appear the most modern and have a minimal effect visually.

CONNECTIONS AND JOINTS

The methods used to secure support structures are vitally important to the success of facade greening. The structural members may be able to accommodate the load imposed by plants, but if they are not equally strong in their interconnections, the framing may fail. The walls and surfaces the system will be connected to requires close examination. Load bearing walls are typically the best option to attach a support structure. Concrete, brick, or stone walls allow for fixings to be directly secured to them. Other situations demand the use of some ingenuity, especially any wall with a cladding system. Exterior finishes and cladding are not load bearing, and while they can be drilled or tapped to reach the structural elements beneath them, the exact location of load bearing members must be known beforehand. In some cases, the freedom and spacing of the facade greening support frame will be dictated by the location of suitable supports to be attached to. This is particularly true in the case of steel construction. Columns may be placed too far apart to be conducive to facade greening supports. In these instances, framing elements may originate from the ground plane rather than be placed directly on the wall surface.

The development of facade greening vegetation can be largely attributed to the support structure selected. Choices regarding material, size, orientation, and connections are all important considerations vital to promote a successful greening project. With the proper supports in place, facade greening can extend to heights of 24 meters (78 feet).[223] Certain species of climbers have the potential to reach 30 meters (98 feet), but it is sensible to

[223] Nigel Dunnett and Noel Kingsbury, *Planting Green Roofs and Living Walls* (Portland: Timber Press, 2004), 147.

plan for significantly shorter reaches. Modern advances in materiality now offer a wide range of trellis structures.

WOODEN SUPPORTS

Traditionally, wood proved the easiest material to provide a guide structure for facade greening. It was cheap, widely available, and lightweight compared to metal frames. They were typically lattice or some variation of a criss-crossed pattern. If properly treated and weatherproofed, wooden trellis can potentially last up to 25 years before any repair work is required.[224] If a portion of the trellis needs to be replaced self-clingers, tendrils, and ramblers can be removed and reattached after installation. Twining climbers, however, do not allow for easy removal and replacement since their stems wrap extensively around the support structure.

Certain measures can be taken to guarantee the maximum lifespan of a wood trellis. Dense growth on the structure increases the rate of deterioration, especially in climates with heavy moisture. Placing a wooden trellis a few inches off the facade surface provides an airspace that will allow for better air circulation, and in the long run, extend the life of the supports. Along with installation and placement of the trellis, the material or type of wood can greatly increase the durability. Oak, elm, and other dense wood will last the longest.

METAL TRELLIS

Metal provides a more permanent solution than a wooden trellis. If treated correctly and made corrosion-proof, a metal trellis can easily outlast the plants it guides. Stainless steel provides the longest lasting alternative. Galvanized steel may also be utilized but has the widest range of varying results. The minimum recommended thickness for a galvanized structure is 55 millimeters (2.2 inches) and coated in zinc with at least 380 grams per

[224] Nigel Dunnett and Noel Kingsbury, *Planting Green Roofs and Living Walls* (Portland: Timber Press, 2004), 148.

square meter (1.14 ounces per square foot).[225] It can easily last 10-20 years in urban conditions, and while it would last a great deal longer in rural settings, metal is subject to corrosion in coastal areas and would only function properly for 5-10 years.

Stainless steel or aluminum framing provide a better support system in areas affected by the salt content of any nearby oceanic bodies. Plastic coated products also offer a long-term solution in highly corrosive environments. In ideal situations, absent of aerial contaminants that accelerate deterioration, steel rebar can be used to form a support structure. Though it would add a considerable amount of weight to the frame, rebar is extremely strong and can be bent and contorted into curves and angles to express a more sculptural appearance. Regardless of the actual metal used, it is wise to paint it in a light, dull color or else the metal will absorb a lot of heat and inhibit plant growth. If the metal support structure gets too hot, the roots and stickers of climbers shy away from attaching themselves. Similar to wooden trellis, if an airspace can be maintained between the structure and facade surface, the airflow will help to cool the metal frame.

TENSILE SUPPORTS

Wire-type supports offer a durable and lightweight option. They are flexible, pliable, and provide numerous grappled connections for climbers to fix to. Most wire members are passed through fixings known as "vine-eyes." Typical fashion is to run wires horizontally through the vine-eyes at 2 meters (6 feet) apart and retain 30-50 centimeters (12-20 inches) vertical spacing.[226] Tensile supports can have a minimal visual impact but they cannot be used to support a facade greening project reaching more than two-stories. Furthermore, unless there are tightening attachments at the end of each run of wire, they can look slack and sag, detracting from the overall appearance.

Traditionally steel wire supports were stretched only horizontally, however modern applications have begun to implement wires also as vertical elements. High-tensile

[225] Nigel Dunnett and Noel Kingsbury, *Planting Green Roofs and Living Walls* (Portland: Timber Press, 2004), 149.
[226] Nigel Dunnett and Noel Kingsbury, *Planting Green Roofs and Living Walls* (Portland: Timber Press, 2004), 150.

stainless steel wires offer structural stability never before considered an attribute of the material. Cross clamps hold the cables together where they intersect. For additional growing surface, steel nets can be stretched between vertical and horizontal cables.

OTHER SUPPORT STRUCTURE MATERIALS

There is a new generation of glass fiber products being developed and promise extremely light and sturdy solutions. They have great tensile strength so long as the diameter is at least 7.75 millimeters (0.31 inches) and have a glass content of at least 80 percent.[227] A coating may be required to provide a rough, uneven surface for vegetation to grasp. Since it is a relatively new development, glass fiber products tend to be rather expensive. If financial backing is not a concern, they can provide one of the best design solutions for any facade greening project.

Rope can also be used for some facade greening. While supplying a rough surface for plants to thrive on, constant exposure to the elements leads to rapid deterioration. As such, rope is a very cheap option and should be used for temporary supports.

11.2 ADVANTAGES AND DISADVANTAGES

Façade greening is traditionally the most common method of vertical gardens. Its simplicity is an advantage that sets it apart from the other two methods. Façade greening does not require a large amount of soil or planted surface. Clingers and climbers only require a growing bed at located at either the base of a wall or the top. Vegetation will grow up or down, depending on the bed location, and eventually envelope the entire wall surface. When façade greening vegetation is seeded, plants are spaced out and generally given a liberal amount of surface to grow along. Singular planted areas demand less watering and will not need a complex water delivery system. Drainage is also easily accommodated.

[227] Nigel Dunnett and Noel Kingsbury, *Planting Green Roofs and Living Walls* (Portland: Timber Press, 2004), 151.

Since façade greening vegetation only requires a growing bed at the top or bottom of a surface, the subsequent structure to promote development is much lighter than the other two vertical garden methods. Simple wire structures, mesh, or trellis-type materials are more than adequate. Most can be attached directly to an exterior wall without additional structural considerations. Minimal material and structural integrity translates to lower costs and maintenance.

Facade greening creates a blend between built and natural environments. Often times vegetation can completely mask the facade of a building. While still an indirect encounter with nature, it successfully shifts perception from a predominantly built environment to a balance of natural and manmade.

Facade greening promotes behavioral and constructivist educational theories. As with most vertical gardens, they elicit curiosity and wonder, encouraging interaction and exploration. Facade greening also has the potential to support cognitive functions depending on the complexity of materials used. Children can potentially learn hierarchical ordering and categorization by examining the relationship between facade greening material and its corresponding structure.

Some of the advantages of façade greening also prove to be its downfall when evaluating it in regards to biophilic principles. Environmental features are generally expressed by all three types of green walls with the exception of fire. Light and space along with the natural shapes and forms category have an equal number of applicable principles, but are not influenced by specific areas like shells and spirals, reflected light, or arches, vaults, and domes. Two biophilic principle categories prevent facade greening from being the ideal vertical garden method for childhood development: natural patterns and processes; and evolved human-nature relationships.

Natural patterns and processes govern diversity and the amount of stimulation an environment can potentially convey. Children inherently look for patterns and similarities to organize complex situations. Unfortunately, facade greening, due to the nature of the plants selected, does not have the amount of variation to promote higher

cognitive functions. Though multiple plants may be employed, their linear growth method can only produce vertical patterns with no organic curves or forms. The minimal amount of stimulation will not invoke that maximal amount of curiosity and need for exploration in children. The evaluation of facade greening according to biophilic principles is demonstrated by Table 8.

Façade Greening

Biophilic Attributes

- Directly applies to vertical garden system (1 point)
- Potentially applies to vertical garden system (0.5 points)
- Does not apply to vertical garden system (0 points)

Environmental Features

- Color
- Water
- Air
- Sunlight
- Plants
- Animals
- Natural materials
- Views and vistas
- Façade greening
- Geology and landscape
- Habitats and Ecosystem
- Fire

Natural Shapes and Forms

- Botanical motifs
- Tree and columnar supports
- Animal (mainly vertebrate) motifs
- Shells and spirals
- Egg, oval, and tubular forms
- Arches, vaults and domes
- Shapes resisting straight lines and right angles
- Simulation of natural features
- Biomorphy
- Geomorphology
- Biomimicry

Natural Patterns and Processes

- Sensory variability
- Information richness
- Age, change, and the patina of time
- Growth and efflorescence
- Central focal point
- Patterned wholes
- Bounded spaces
- Transitional spaces
- Linked series and chains
- Integration of parts to wholes
- Complementary contrasts
- Dynamic balance and tension
- Fractals
- Hierarchically organized ratios and scales

Light and Space

- Natural light
- Filtered and diffused light
- Light and shadow
- Reflected light
- Light pools
- Warm light
- Light as shape and form
- Spaciousness
- Spatial variability
- Space as shape and form
- Spatial harmony
- Inside-outside space

Place-Based Relationships

- Geographic connection to place
- Historic connection to place
- Ecological connection to place
- Cultural connection to place
- Indigenous materials
- Landscape orientation
- Landscape features that define building form
- Landscape ecology
- Integration of culture and ecology
- Spirit of place
- Avoiding placelessness

Evolved Human-Nature Relationships

- Prospect and refuge
- Order and complexity
- Curiosity and enticement
- Change and metamorphosis
- Security and protection
- Mastery and control
- Affection and attachment
- Attraction and beauty
- Exploration and discovery
- Information and cognition
- Fear and awe
- Reference and spirituality

SCORE

48.5

MFO Park

Year: 2002
Location: Zurich, Switzerland
Building Type: Park, Open Space

Designers/Manufacturers of Record:
Burckhardt + Partner AG and Raderchall Landschaftsarchitekten AG

Figure 29: MFO Exterior

Figure 30: MFO Interior 2

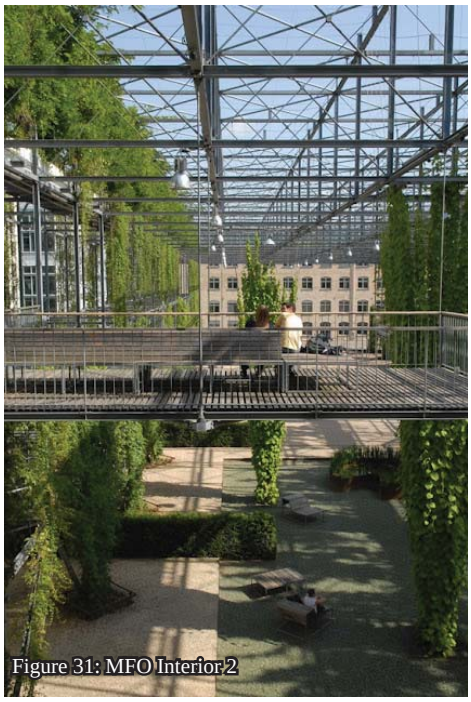

Figure 31: MFO Interior 2

[228] http://3.bp.blogspot.com/-7j-cohZUje8/ThlYb5i986I/AAAAAAAAAYs/xbNuBtREpao/s1600/mfo+park-outside.jpg
[229] http://vantegarden.blogspot.com/2011/07/mfo-park.html
[230] http://vantegarden.blogspot.com/2011/07/mfo-park.html

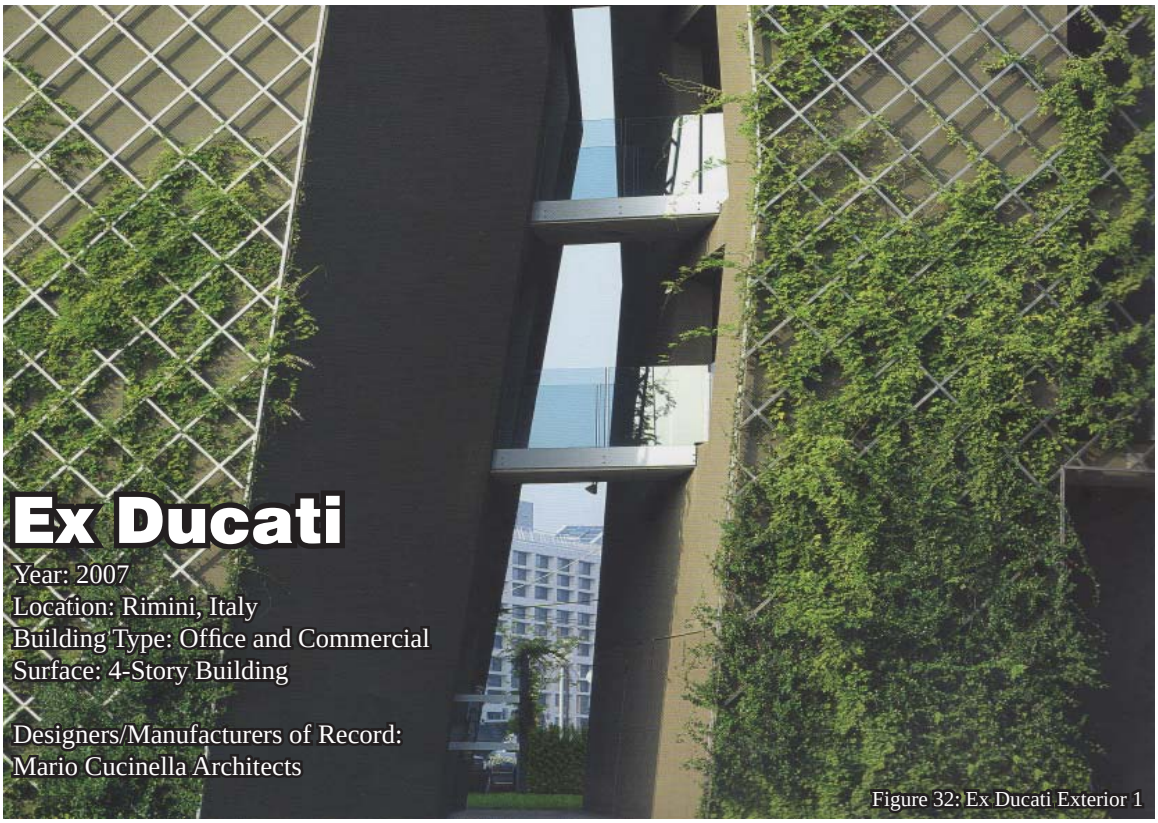

Figure 32: Ex Ducati Exterior 1

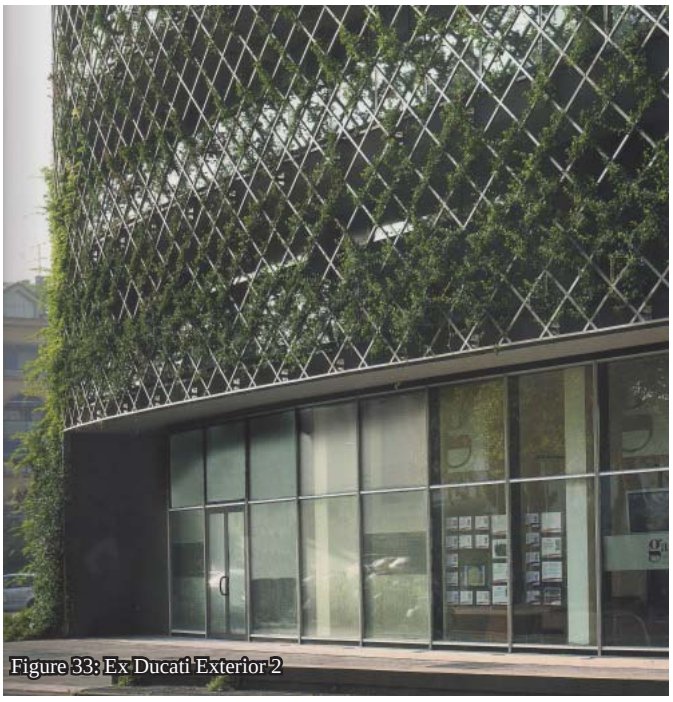
Figure 33: Ex Ducati Exterior 2


Figure 34: Ex Ducati Exterior 3

[231] Anna Lambertini, *Vertical Gardens* (London: Verba Volant Ltd.,2007), 132.
[232] Anna Lambertini, *Vertical Gardens* (London: Verba Volant Ltd.,2007), 133.
[233] http://www.designtopnews.com/wp-content/uploads/2009/03/ex-ducati-by-mario-cucinella-architects-rimini-italy-5.jpg

12.0 PLANTER WALLS

Planter walls are the least common type of vertical garden. Though their appearance is rather infrequent, they are still worth mentioning. Planter walls consist of pots, planter boxes, or other similar vessels mounted along the vertical surface of a building. In some instances they use unconventional materials like tires, concrete masonry units, or reused materials to serve as growing beds. Conventional soil and other growing mediums are held within an object and are typically uniform in appearance. The depth of each planter box and density of the soil is determined by the plants used.

Planter walls require the most structural work of all three vertical gardens. The planters employed are generally constructed of metal for durability, and as such, add a substantial amount of weight to the system. These planters are fastened to metal framing or the exterior of a building if designed to support the extra load.

Though planter walls may demand the most structural work, the average amount of soil or growing medium is considerably more than facade greening or green walls. A larger depth in soil allows for sizable plants to be selected for a design. These bigger plants can provide more shade, aesthetic interest, and a greater range of variation in vegetation.

Of the three vertical garden techniques, planter walls represent a largely built quality. While still providing an indirect experience with nature, their structure and potted compartments lend themselves to a largely built environment.

12.1 ADVANTAGES AND DISADVANTAGES

Planter walls are the least appropriate vertical gardening technique for promoting childhood development. They encompass much the same educational theories as any method of vertical gardening. Behavioral and constructivist theories are supported, though to a slightly lesser degree because of the structural and built components taking precedence over the vegetation. It is also because of the structure and connections that planter walls enforce cognitive theories. Realization of parts composing an integral whole is valuable to an understanding of planter walls.

Planter walls have several shortcoming when evaluating them based on biophilic principles. While still portraying the same amount of qualities from environmental features, natural shapes and forms, and light and space, they fall short in natural patterns and processes and evolved human-nature relationships. Planter walls generally have modular features leading to static appearances and a lack of complexity. While they enforce pattern recognition the lack of diversity does not require much critical thinking. Planter walls also have a difficult time eliciting curiosity and exploration since their function, aesthetic value, and purpose are generally deduced at first glance. The evaluation of planter walls based on biophilic principles is shown in Table 9.

Planter Walls

Biophilic Attributes

■	Directly applies to vertical garden system	(1 point)
■	Potentially applies to vertical garden system	(0.5 points)
□	Does not apply to vertical garden system	(0 points)

Environmental Features

- ■ Color
- ■ Water
- ■ Air
- ■ Sunlight
- ■ Plants
- ■ Animals
- ■ Natural materials
- ■ Views and vistas
- ■ Façade greening
- ■ Geology and landscape
- ■ Habitats and Ecosystem
- Fire

Natural Shapes and Forms

- ■ Botanical motifs
- ■ Tree and columnar supports
- ■ Animal (mainly vertebrate) motifs
- ■ Shells and spirals
- ■ Egg, oval, and tubular forms
- ■ Arches, vaults and domes
- ■ Shapes resisting straight lines and right angles
- ■ Simulation of natural features
- Biomorphy
- ■ Geomorphology
- ■ Biomimicry

Natural Patterns and Processes

- Sensory variability
- Information richness
- ■ Age, change, and the patina of time
- ■ Growth and efflorescence
- ■ Central focal point
- ■ Patterned wholes
- ■ Bounded spaces
- ■ Transitional spaces
- ■ Linked series and chains
- ■ Integration of parts to wholes
- ■ Complementary contrasts
- ■ Dynamic balance and tension
- ■ Fractals
- ■ Hierarchically organized ratios and scales

Light and Space

- ■ Natural light
- ■ Filtered and diffused light
- ■ Light and shadow
- ■ Reflected light
- ■ Light pools
- ■ Warm light
- ■ Light as shape and form
- ■ Spaciousness
- ■ Spatial variability
- ■ Space as shape and form
- ■ Spatial harmony
- Inside-outside space

Place-Based Relationships

- Geographic connection to place
- Historic connection to place
- ■ Ecological connection to place
- ■ Cultural connection to place
- ■ Indigenous materials
- ■ Landscape orientation
- Landscape features that define building form
- Landscape ecology
- ■ Integration of culture and ecology
- ■ Spirit of place
- ■ Avoiding placelessness

Evolved Human-Nature Relationships

- ■ Prospect and refuge
- ■ Order and complexity
- ■ Curiosity and enticement
- ■ Change and metamorphosis
- ■ Security and protection
- ■ Mastery and control
- ■ Affection and attachment
- ■ Attraction and beauty
- Exploration and discovery
- Information and cognition
- ■ Fear and awe
- ■ Reference and spirituality

SCORE

42.5

Figure 35: Tokyo Swatch Interior 1

Figure 36: Tokyo Swatch Interior 2

Figure 37: Tokyo Swatch Interior 3

[234] Author
[235] Author
[236] Author

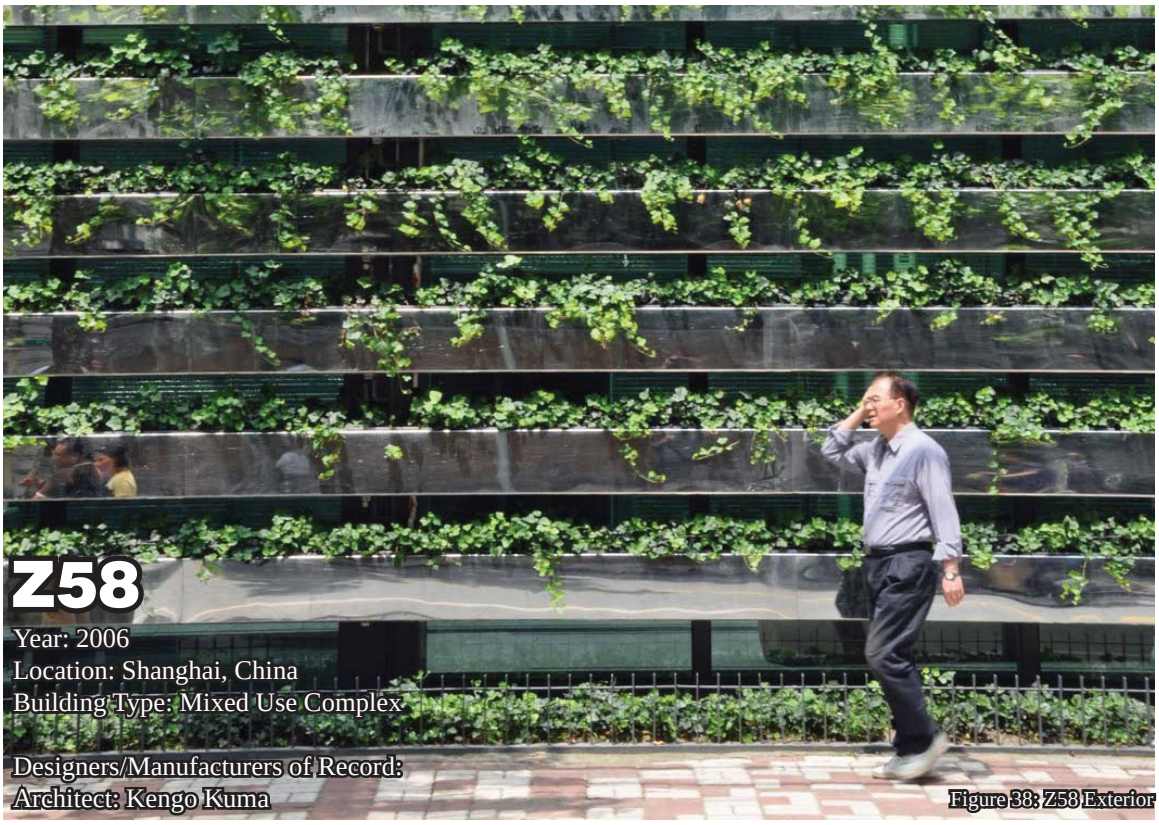

Figure 38: Z58 Exterior


Figure 39: Z58 Interior 1


Figure 40: Z58 Interior 2

[237] http://cwfoodtravel.blogspot.com/2010/07/shanghai-2010-z58.html
[238] http://cwfoodtravel.blogspot.com/2010/07/shanghai-2010-z58.html
[239] http://cwfoodtravel.blogspot.com/2010/07/shanghai-2010-z58.html

13.0 GREEN WALLS

Vertical gardens are rapidly increasing in popularity for their aesthetic value. The benefits and advantages go far beyond simply visual quality, although it is the most apparent gain. While some may consider vertical gardens and facade greening to be one in the same, they are two completely separate disciplines. Facade greening relies on vines and climbers that grow from the ground up, whereas vertical gardening incorporates growing medium, irrigation, and vegetation throughout the whole wall.

While vertical gardening has emerged with many different systems, most of them still retain a planter with some type of soil medium for the plants to be placed in. This project will focus on one of the most innovative vertical garden designs that emanates from the French designer, Patrick Blanc. His innovative system minimizes the amount of support structure needed and eliminates the need for a soil medium. It is composed of a rustproof steel frame, expanded polyvinyl chloride (PVC) panels, a double layer of irrigation cloth, polyurethane tubes for watering, and the plants. Even using a substantially heavy frame, the vertical garden will not exceed 50 kilogram per square meter (100 pounds per square foot) and generally weighs closer to 20 kilograms per square meter (40 pounds per square foot).[240]

METAL FRAMING

The paneled backing of the vertical garden system could be directly affixed to a building or structure, but it is better to have an airspace between for insulation purposes. An aluminum, galvanized steel, or stainless steel frame is installed in a grid-like fashion. The framing members are metal tubes 4 centimeters (1.5 inches) thick and are spaced evenly to accommodate the PVC panels of 1.22 x 2.44 meters (47.6 x 95.2 inches), which is the standard size.[241] Occasionally only the vertical tubes are installed and a horizontal

[240] Patrick Blanc, *The Vertical Garden: From Nature to the City* (New York: W.W. Norton & Company, Inc, 2008), 99.
[241] Patrick Blanc, *The Vertical Garden: From Nature to the City* (New York: W.W. Norton & Company, Inc, 2008), 99.

bar is placed where the PVC members join. The panels are riveted to the metal frame, and where necessary, a silicone-based seal is applied.

POLYVINYL CHLORIDE PANELS (PVC)

Polyvinyl chloride panels are utilized for their lightweight and durable nature. A 10 millimeter thick (0.4 inches) weights only 7 kilograms per square meter (15 pounds per square yard). The material is capable of withstanding the stress imposed by the materials fastened to its surface. PVC is capable of tolerating a 100 kilogram per centimeter square (1,500 pound per square yard) force, which is well below the approximate strength exerted by larger shrubs in windy conditions.[242] The durable nature of the panels also allows materials to be stapled onto the surface without cracking or shattering.

IRRIGATION CLOTH

The intriguing aspect of Blanc's *mur vegetal* is his recognition of a plants ability to grow on a surface rather than in a volume, as is the usual case. The use of felt, or irrigation cloth, promotes the spread of roots along the surface rather than burrowing deeper. This removal of a substrate or growing medium significantly reduces the weight of a vertical garden. A 3 millimeter (0.1 inch) substrate weighs 3 kilograms per square meter (6.5 pounds per square yard) when wet, compared to a 2 centimeter (0.75 inch) medium weighs 20 kilograms per square meter (44 pounds per square yard) when soaked, and even still, a 10 centimeter (4 inch) substrate weighs 100 kilograms per square meter (220 pounds per square yard) when drenched.[243] Furthermore, the felt substrate is not subject to the same settlement patterns as conventional soil medium and does not suffer as much deformation from temperature change. The irrigation cloth is protected from rot through the incorporation of recycled acrylic textiles. The cloth is reinforced by a film of polypropylene inserted between the PVC boards and the felt layers.

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[242] Patrick Blanc, *The Vertical Garden: From Nature to the City* (New York: W.W. Norton & Company, Inc, 2008), 98.
[243] Patrick Blanc, *The Vertical Garden: From Nature to the City* (New York: W.W. Norton & Company, Inc, 2008), 97.

The felt is composed of two layers and secured to the PVC boards by rust-proof staples. A horizontal slit is cut into the top sheet in desired locations for planting. Once the plants are removed from their potted origins, they are inserted into the slit and fastened by more staples to either side. Once the selected plants are in place, their roots slowly spread in all directions since they are not hindered by the constraints of a given volume.

All biological interaction takes place between plant and irrigation cloth. Important micro-processes necessary for plant development occur within these layers, most notably mycorrhiza. This process is the interaction between fungus and roots and allow for better absorption of water and minerals by the roots. Some bacteria also cultivate and help with plant development. Most processes crucial to root growth are stimulated when well oxygenated. Since the felt is exposed directly to the air, maximum growth can potentially be achieved. The accumulation of microorganisms near the roots of the plants are not only vital for the plant life, but they also help to transform mild toxic materials like pesticides and volatile organic compounds (VOCs) emitted by industrial areas, vehicles, and human activities.[244] These harmful compounds along with dust and other pollutants are displaced on the surface of the leaves and the surface. Over time, they are broken down into elements that the plants can absorb for nutrition. Through this chemical types of breakdowns and recycling, the irrigation cloth and plants can act as filters for wastewater.

WATERING AND FERTILIZING

Water is provided through a low-density polyurethane tube placed horizontally across the top of the vertical garden in order to provide a top-down watering system. Holes approximately 2 millimeters in diameter (0.08 inches) are placed every 10 millimeters (4 inches) apart. As long as the piping does not exceed 10 meters (33 feet) in length there should be sufficient water pressure to allow for even water distribution. Watering normally takes place 3-5 times a day and each session lasts for about 2-3 minutes. A

[244] Patrick Blanc, *The Vertical Garden: From Nature to the City* (New York: W.W. Norton & Company, Inc, 2008), 98.

vertical garden can require between 0.5-5 liters of water per square meter (1-10 pints per square yard). Properly maintained, an outdoor application in a temperate climate can require 3 liters per square meter (3 quarts per square yard), and an indoor vertical garden needs 1 quart per square meter.[245] In either case, the amount of water is substantially lower than the amount needed for a conventional garden or urban park.

In order to supplement the lack of soil to provide the minerals needed for plant growth, a nutritive solution of water is used. If the water is collected from water catchment of any sort, the mixture is diluted since there will be a lack of calcium carbonate, or lime, which inhibits the absorption of nutrients. In applications where an aquarium, pool, or wastewater is used as a source, an additive solution is not necessary.

MAINTENANCE

Once the plants of a vertical garden begin to take root and flourish, maintenance is usually relegated to a few annual inspections. If carefully selected, some plants will never require intervention. Shrubs and vegetation with well developed stems may necessitate occasional pruning. The branches of any plant should not be allowed to stray more than 2 yards from the wall or it runs the risk of breaking off. Care for a wall 3-8 meters (10-25 feet) can be carried out by ladder, but vertical gardens 10-30 meters (30-100 feet) need the aid of a mechanical lift.

13.1 ADVANTAGES AND DISADVANTAGES

Green walls retain the most organic appearance. They are not as limited by growing medium or support structure since most designs create a singular, large area for plants to flourish. Since green walls do involve a moderately complex structure to ensure stability, they have the potential to harbor benefits to cognitive educational theories. The hierarchy and ordering of connections enforce critical thinking and problem solving. The plants of

[245] Patrick Blanc, *The Vertical Garden: From Nature to the City* (New York: W.W. Norton & Company, Inc, 2008), 98.

a green wall are often diverse in color, size, shape, and even smell. As such, they provoke exploration by viewers and support behavioral as well as constructivist theories.

Green walls net the most advantages, according to the evaluation based on biophilic attributes, of the three vertical garden systems. The complexity of support structure combined with a wide range of vegetation establish majority of the attributes from environmental features; natural shapes and forms; natural patterns and processes; and evolved human-nature relationships. Green walls excel in expressing organic forms, unique patterns, and shapes resisting straight lines. The evaluation of green walls based on biophilic principles are demonstrated in Table 10.

Green Walls

Biophilic Attributes

■	Directly applies to vertical garden system	(1 point)
■	Potentially applies to vertical garden system	(0.5 points)
□	Does not apply to vertical garden system	(0 points)

Environmental Features

- ■ Color
- ■ Water
- ■ Air
- ■ Sunlight
- ■ Plants
- ■ Animals
- ■ Natural materials
- ■ Views and vistas
- ■ Façade greening
- ■ Geology and landscape
- ■ Habitats and Ecosystem
- Fire

Natural Shapes and Forms

- ■ Botanical motifs
- ■ Tree and columnar supports
- ■ Animal (mainly vertebrate) motifs
- Shells and spirals
- ■ Egg, oval, and tubular forms
- Arches, vaults and domes
- ■ Shapes resisting straight lines and right angles
- ■ Simulation of natural features
- ■ Biomorphy
- ■ Geomorphology
- ■ Biomimicry

Natural Patterns and Processes

- ■ Sensory variability
- ■ Information richness
- ■ Age, change, and the patina of time
- ■ Growth and efflorescence
- ■ Central focal point
- ■ Patterned wholes
- ■ Bounded spaces
- ■ Transitional spaces
- ■ Linked series and chains
- ■ Integration of parts to wholes
- ■ Complementary contrasts
- ■ Dynamic balance and tension
- ■ Fractals
- ■ Hierarchically organized ratios and scales

Light and Space

- ■ Natural light
- ■ Filtered and diffused light
- ■ Light and shadow
- Reflected light
- ■ Light pools
- ■ Warm light
- Light as shape and form
- ■ Spaciousness
- ■ Spatial variability
- ■ Space as shape and form
- ■ Spatial harmony
- ■ Inside-outside space

Place-Based Relationships

- Geographic connection to place
- Historic connection to place
- ■ Ecological connection to place
- ■ Cultural connection to place
- ■ Indigenous materials
- ■ Landscape orientation
- ■ Landscape features that define building form
- ■ Landscape ecology
- ■ Integration of culture and ecology
- ■ Spirit of place
- ■ Avoiding placelessness

Evolved Human-Nature Relationships

- ■ Prospect and refuge
- ■ Order and complexity
- ■ Curiosity and enticement
- ■ Change and metamorphosis
- ■ Security and protection
- ■ Mastery and control
- ■ Affection and attachment
- ■ Attraction and beauty
- ■ Exploration and discovery
- ■ Information and cognition
- ■ Fear and awe
- ■ Reference and spirituality

SCORE

56.5

Caxia Forum

Year: 2006
Location: Madrid, Spain
Building Type: Museum
Surface: 24 meter high wall (79 ft.)

Designers/Manufacturers of Record:
Architect: Herzog & de Mueron
Green Wall Designer & Installation: Patrick Blanc

Figure 41: Caxia Forum Courtyard

Figure 42: Caxia Forum Green Wall Planting

Figure 43: Caxia Forum Material Contrast

[246] http://architecture.mapolismagazin.com/sites/blog1b/files/styles/blog-post_page_full/public/caixa-forum-3.jpg
[247] http://media.photobucket.com/image/caixa%20forum/stashpocketblog/HerzogDeMeuron_CaixaForum/HerzogDe-Meuron_CaixaForum7.jpg
[248] http://4.bp.blogspot.com/_i3N9xRlzY4U/SBBjZ0PmpOI/AAAAAAAAAN8/Nxo-UjfUA1g/s1600/caixaforum.JPG

Figure 44: Musée du quai Branly Exterior 1


Figure 45: Musée du quai Branly Exterior 2

Figure 46: Musée du quai Branly Side Exterior

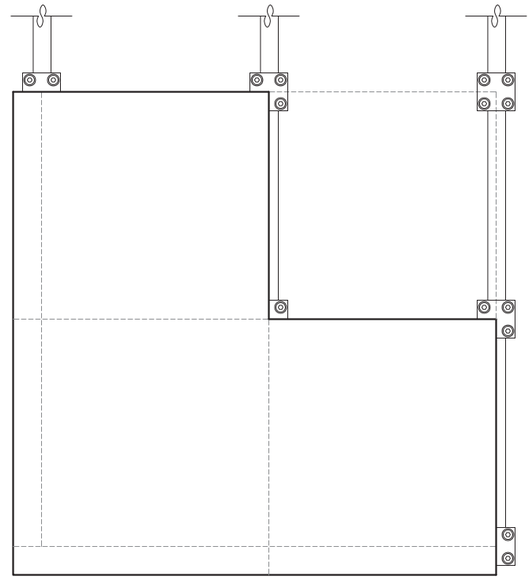
[249] https://www2.bc.edu/~javel/musee-du-quai-branly-4.jpg
[250] http://www.spicelines.com/IMG_0042.jpg
[251] http://3.bp.blogspot.com/-oxbGou-mJ4A/TVhqsbL-z0I/AAAAAAAAAVk/g_n_vtoiW9A/s1600/Musee_Quai_Branly_mur.jpg

14.0 DESIGN IMPLICATIONS

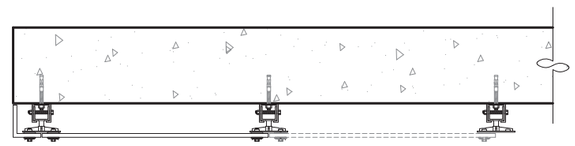
After careful examination of all three vertical garden types, green walls were deemed the best option for promoting childhood development in a residential setting. Residences were chosen over other building types since studies have shown that children spend a majority of their time at home. Green walls are ideal for their trifecta of benefits. First, green walls are a vertical application and allow for the maximum of floor area to be utilized. When polled for ideal home conditions, children generally favored a lawn for outdoor activity. Green walls will take up less area than landscaped gardens and still provide the benefits of an indirect experience with nature. Second, green walls are more engaging than green roofs. Green roofs can only be enjoyed and experienced if one has access to it. They are also not readily visible for aesthetic value and most homes are not built to carry the additional load. The primary reason of green roofs are to cool a dwelling, but there are often cheaper ways to do so such as elastomeric coatings. Furthermore, the roof is valuable real estate for the placement of solar hot water or photovoltaics. Third, green walls are potentially more beneficial in terms of cooling. Even in a two-story building the square footage of an exterior wall may exceed that of the roof. Green walls can be employed on the south facing wall for maximal heat abatement.

Green walls provide benefits to all educational theories, types of transfer, and biophilic values. They also encompass the most biophilic attributes. For the purpose of this project, suggestions for the beginnings of a modular wall system will be made. Potential uses and applications will be discussed. Green walls, as elegant as they are, can be viewed as an elaborate wall treatment. While eliciting interest from viewers they could conceivable be much more tantalizing through the incorporation of secondary elements. These complementary components are also explained.

Green Walls



ELEVATION (TYP.)



PLAN (TYP.)

MODULAR GREEN WALL

SCALE: 3/4" = 1'-0"

0' 0.5' 1' 2' 3'

Figure 47: Modular Green Wall Plan and Elevation (Typ.)

Figure 48: Green Wall Elevation (Typ.)

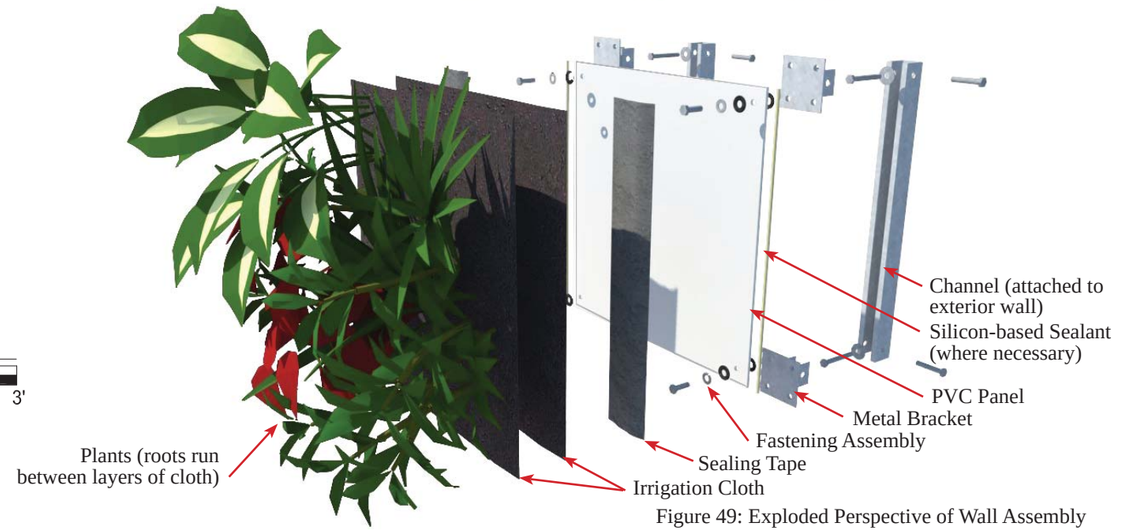


Figure 49: Exploded Perspective of Wall Assembly

Educational Theories
- Cognitive
- Behavioral
- Constructivist

Transfer Types
- Near
- Far
- Literal
- Figural
- Low Road
- High Road

Biophilic Values
- Aesthetic
- Dominionistic
- Humanistic
- Moralistic
- Naturalistic
- Negativistic
- Scientific
- Symbolic
- Uilitarian.

Biophilic Attributes

Environmental Features
- Color
- Water
- Air
- Sunlight
- Plants
- Animals
- Natural materials
- Façade greening
- Geology and landscape
- Habitats and Ecosystem

Natural Shapes and Forms
- Botanical motifs
- Tree and columnar supports
- Arches, vaults and domes
- Shapes resisting straight lines
- Simulation of natural features
- Biomorphy
- Geomorphology

Natural Patterns and Processes
- Sensory variability
- Information richness
- Age, change, and patina of time
- Growth and efflorescence
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- Fractals
- Hierarchically organized objrects

Light and Space
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- Spatial variability
- Space as shape and form
- Spatial harmony
- Inside-outside space

Place-Based Relationships
- Ecological connection to place
- Indigenous materials
- Landscape orientation
- Landscape that define form
- Landscape ecology
- Integration of culture/ecology
- Spirit of place
- Avoiding placelessness

Evolved Human-Nature Relationships
- Prospect and refuge
- Order and complexity
- Curiosity and enticement
- Change and metamorphosis
- Security and protection
- Mastery and control
- Affection and attachment
- Attraction and beauty
- Exploration and discovery
- Information and cognition
- Fear and awe
- Reference and spirituality

Figure Credits:
Figure 47: Author
Figure 48: Author
Figure 49: Author

Green Walls

Figure 50: Indoor-Outdoor Connection

Figure 51: Bounding Wall Application

Figure Credits:
Figure 50: Author
Figure 51: Author

Figure 52: Multi-Story Application

Figure Credits:
Figure 52: Author

Green Wall Column/Screen

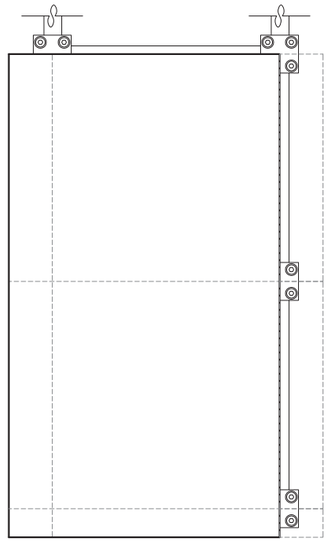

Figure 53: Green Wall Column/Screen Plan and Elevation (Typ.)

Figure 54: Green Wall Column

Biophilic Attributes

Environmental Features
- Color
- Water
- Air
- Sunlight
- Plants
- Animals
- Natural materials
- Façade greening
- Geology and landscape
- Habitats and Ecosystem

Natural Shapes and Forms
- Botanical motifs
- Tree and columnar supports
- Arches, vaults and domes
- Shapes resisting straight lines
- Simulation of natural features
- Biomorphy
- Geomorphology

Natural Patterns and Processes
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Place-Based Relationships
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Evolved Human-Nature Relationships
- Prospect and refuge
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- Affection and attachment
- Attraction and beauty
- Exploration and discovery
- Information and cognition
- Fear and awe
- Reference and spirituality

Educational Theories
- Cognitive
- Behavioral
- Constructivist

Transfer
- Near
- Far
- Literal
- Figural
- Low Road
- High Road

Biophilic Values
- Aesthetic
- Dominionistic
- Humanistic
- Moralistic
- Naturalistic
- Negativistic
- Scientific
- Symbolic
- Uilitarian.

Figure Credits:
Figure 53: Author
Figure 54: Author

Green Wall Column/Screen

Figure 55: Green Wall Angled Screen

Figure 56: Green Wall Screen at Angled Intervals

Figure 54: Green Wall Screen at Intervals

Potential Applications

Figure Credits:
Figure 55: Author
Figure 56: Author
Figure 57: Author

Potential Design

Figure Credits:
Figure 58: Author

Additional Components

Figure Credits:
Figure 59: Author

15.0 CONCLUSION

After extensive research and the preliminary stages of design, it is evident that green walls provide an excellent environment for childrearing. They provide enough stimulation and diversity to support all facets of environmental psychology but present nature in a subtle way that does not lead to sensory overload. In combination environmental perception, green walls encompass all types of educational theory. They supply enough variety to even enhance cognitive development. The unique vertical application of green walls conceivably triggers every kind of transfer as well. Seeing plants and vegetation presented in such an unusual fashion should prompt children to ponder innovative applications for other seemingly normal processes. This type of creativity will increase the rate at which educational theories are advanced.

Children will make substantial gains in cognitive, affective, and evaluative development in the presence of green walls. Formation of all biophilic values will come naturally as a child matures. Their views may change, but a singular green wall has the capacity to portray traits necessary to enforce all values.

Green walls will not only foster a child's learning aptitude, but they will also boast better health and well-being in general. Gains will be made to physical, mental, and even social health. Green walls encourage children to play outdoors and partake in physical activity. Staying active will combat a sedentary lifestyle and can improve strength, stamina, and overall fitness. Playing outdoors is much more conducive to social situations. Children participate in cooperative play, learn teamwork, democratic skills, fair play, leadership, and independence. Green walls can also reduce stress, lower blood pressure, improve attentiveness, speed recovery time for illnesses, and prevent fatigue.

Biophilic attributes are what truly set green walls apart from other vertical garden techniques. They encompass the majority of attributes from all six elements. Their flexibility in vegetative surfaces allows the implementation of traits no other vertical wall

could utilize. The complexity displayed by a green wall far surpasses that of facade greening and planter walls.

Green walls alone are a significant gain for childhood development, but they are limited in that they represent a facade application. To maximize the effectiveness of a green wall, complementary components should be included to encourage more interaction and exploration. These added parts can also supplement the biophillic attributes a green wall may not convey. Creating an entire scene, rather than a singular green wall, will increase gains to physical, mental, and social health.

15.1 FUTURE APPLICATION AND IMPORTANCE

Plants and vegetation are uncommon in dense urban cities and industrial areas due to a lack of open and unpaved surfaces. Green walls provide a means to introduce plant-life into these types of settings. Their vertical application creates a vast amount of planting space in the form of wall surfaces. Adaptive reuse also provides excellent opportunities to incorporate vertical gardens. Many warehouses built in the nineteenth and twentieth century, which have fallen into disrepair, are being converted into mixed use buildings, apartments, or loft spaces. The introduction of plant life will significantly soften the dreary nature that is usually typical of industrial areas.

Green walls can also be used to cover noise barriers, road dividers, and similar structures. They would greatly improve the otherwise blank surfaces, discourage vandalism, and control the dust and debris circulated by vehicular activity. Parking structures are a common sight in urban areas. They are a great solution and cost effective way to provide more parking in cities that do not have the square footage available at ground level. While the additional spaces are a commodity to be sure, parking structures usually display a cold, harsh quality. They are typically raw concrete structures and only painted if any finishing is applied at all. Their dismal appearance would be much less apparent if climbers or planters were added. If enough surfaces were covered in such a manner, not

only would it create a positive visual impact, but could also reduce heat islanding in urban districts.[252]

Heat islanding has a significant impact on high density urban areas. As more buildings, roads, and manmade structures are constructed, the amount of open landscape and vegetation dwindles. Natural surfaces that were once wet and permeable are replaced by dry, impervious materials. As a result, these type of highly developed areas become much warmer than their rural surroundings, in effect, creating an "island" of higher temperature.[253] Elevated temperatures, particularly during the summer, can have negative effects. The hotter conditions increase energy consumption as buildings require more cooling. It can add a lot of pressure to the electrical grid during peak hours of the work day. It is estimated that the heat island effect is accountable for 5-10% of the energy demand for cooling buildings in the city.[254] A byproduct of increased energy demand is that more greenhouse gases, emissions, and air pollutants are created. Higher temperatures are also harmful to human health. They can lead to general discomfort, respiratory difficulties, fatigue and exhaustion, and in some extreme cases, heat stroke or heat-related mortality. Thus, the potential for vertical gardens to mitigate the heat island effect demonstrates their significance in future applications.

The main way urban greenery alleviates heat is through the process of evapotranspiration. The procedure encompasses the combined effect of transpiration, the movement of water through a plant from the time it is absorbed by the roots to expulsions as vapor from the leaves, and evaporation. Both processes are solar powered and the energy is conserved in the water vapor before it has the opportunity to be converted into heat.[255] The larger the vegetated area, the greater the heat mitigation. However, there other factors that affect the efficiency of planted areas. If the vegetation is lower than the surrounding area, or

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[252] Dunnett, Nigel, and Kingsbury, Noel. *Planting Green Roofs and Living Walls* (Portland: Timber Press, 2004), 50-51.
[253] United States Environmental Protection Agency. "Heat Island Effect." http://www.epa.gov/hiri/about/index.htm.
[254] United States Environmental Protection Agency. "Heat Island Effect." http://www.epa.gov/hiri/about/index.htm.
[255] Nigel Dunnett and Noel Kingsbury, *Planting Green Roofs and Living Walls* (Portland: Timber Press, 2004), 51.

surrounded by walls and buildings, it's effectiveness is reduced. Smaller green spaces are only beneficial if they are part of an interspersed collective. Green walls have a near limitless potential, especially in Hawaii, because they will not be affected by seasonal weather.

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